photon focus

User Manual

MV-D1024E-3D01-160

3D CMOS Camera

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1

Preface

1.1 About Photonfocus

The Swiss company Photonfocus is one of the leading specialists in the development of CMOS image sensors and corresponding industrial cameras for machine vision, security & surveillance and automotive markets.
Photonfocus is dedicated to making the latest generation of CMOS technology commercially available. Active Pixel Sensor (APS) and global shutter technologies enable high speed and high dynamic range (120 dB) applications, while avoiding disadvantages like image lag, blooming and smear.
Photonfocus has proven that the image quality of modern CMOS sensors is now appropriate for demanding applications. Photonfocus' product range is complemented by custom design solutions in the area of camera electronics and CMOS image sensors.
Photonfocus is ISO 9001 certified. All products are produced with the latest techniques in order to ensure the highest degree of quality.

1.2 Contact

Photonfocus AG, Bahnhofplatz 10, CH-8853 Lachen SZ, Switzerland

Sales	Phone: +41 55 451 07 45	Email: sales@photonfocus.com
Support	Phone: +41 55 451 01 37	Email: support@photonfocus.com

Table 1.1: Photonfocus Contact

1.3 Sales Offices

Photonfocus products are available through an extensive international distribution network and through our key account managers. Details of the distributor nearest you and contacts to our key account managers can be found at www.photonfocus.com.

1.4 Further Information

For further information on the products, documentation and software updates please see our web site www.photonfocus.com or contact our distributors.

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1.5 Legend

In this documentation the reader's attention is drawn to the following icons:

Important note

Alerts and additional information

Attention, critical warning

Notification, user guide

2

How to get started (CameraLink®)

1. Install a suitable frame grabber in your PC.

   To find a compliant frame grabber, please see the frame grabber compatibility list at www.photonfocus.com.

2. Install the frame grabber software.

   Without installed frame grabber software the camera configuration tool PFRemote will not be able to communicate with the camera. Please follow the instructions of the frame grabber supplier.

3. Remove the camera from its packaging. Please make sure the following items are included with your camera:

   - Power supply connector (7-pole power plug)
   - Camera body cap

   If any items are missing or damaged, please contact your dealership.

4. Remove the camera body cap from the camera and mount a suitable lens.

   When removing the camera body cap or when changing the lens, the camera should always be held with the opening facing downwards to prevent dust or debris falling onto the CMOS sensor.

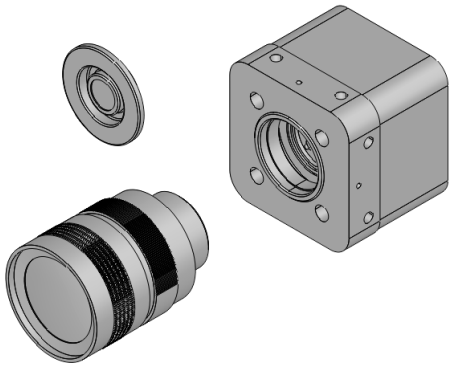

Figure 2.1: Camera with protective cap and lens.

Do not touch the sensor surface. Protect the image sensor from particles and dirt!

The sensor has no cover glass, therefore dust on the sensor surface may resemble to clusters or extended regions of dead pixel.

To choose a lens, see the Lens Finder in the 'Support' area at www.photonfocus.com.

5. Connect the camera to the frame grabber with a suitable CameraLink cable (see Fig. 2.2). CameraLink cables can be purchased from Photonfocus directly (www.photonfocus.com). Please note that Photonfocus provides appropriate solutions for your advanced vision applications.

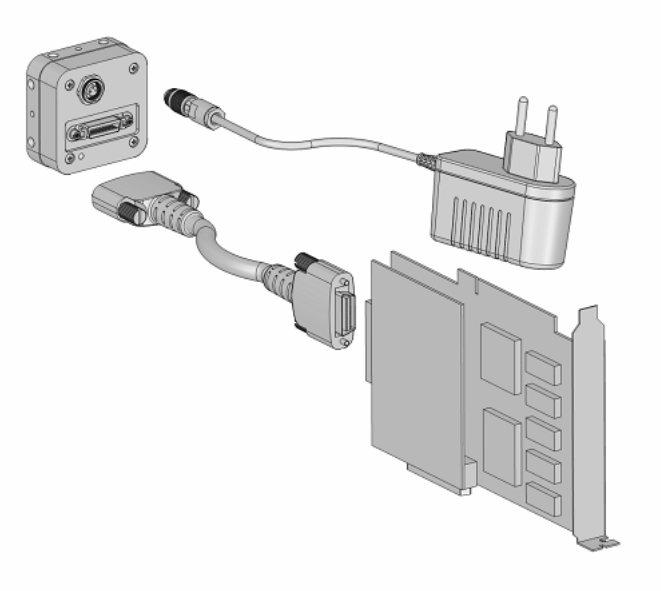

Figure 2.2: Camera with frame grabber, power supply and cable.

Do not connect or disconnect the CameraLink cable while camera power is on! For more information about CameraLink see Section 4.9.

6. Connect a suitable power supply to the provided 7-pole power plug. For the connector assembly see Fig. A.1. The pinout of the connector is shown in Appendix A.

Check the correct supply voltage and polarity! Do not exceed the maximum operating voltage of +12V DC (± 10%).

7. Connect the power supply to the camera (see Fig. 2.2).

The status LED on the rear of the camera will light red for a short moment, and then flash green. For more information see Section 5.1.4.

8. Download the camera software PFRemote to your computer.

You can find the latest version of PFRemote on the support page at www.photonfocus.com.

9. Install the camera software PFRemote. Please follow the instructions of the PFRemote setup wizard.

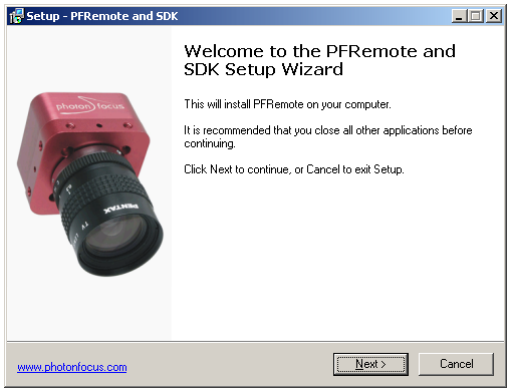

Figure 2.3: Screen shot PFremote setup wizard

10. Start the camera software PFRemote and choose the communication port.

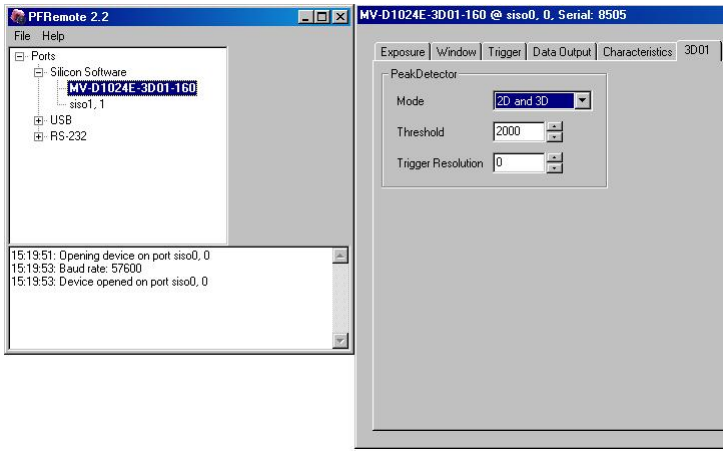

Figure 2.4: PFRemote start window

11. Check the status LED on the rear of the camera.

The status LED lights green when an image is being produced, and it is red when serial communication is active. For more information see Section 5.1.4.

12. You may display images using the software that is provided by the frame grabber manufacturer.

13. The installation procedure and the system configuration of a suitable PCI Express framegrabber needed to operate the 3D Suite from Photonfocus is covered in separate documentations.

You can find more detailled instructions in the application note AN028 "3D System Configuration" in the support area at www.photonfocus.com.

3

Product Specification

3.1 Introduction

The MV-D1024E-3D01-160 is a CMOS camera from Photonfocus optimized in two aspects for laser triangulation applications. The camera includes an image processing module, that runs an algorithm called Peak Detector. The Peak Detector algorithm is able to compute with sub-pixel accurracy the peak position of a laser line. Thus, the height profile of an object gets computed within the camera, making additional calculations in the PC obsolet.
In several applications solved with laser triangulation setups it was shown that the use of the LinLog®response curve leads to better triangulation results, since information is not getting lost by saturation of the laser line. The triangulation is getting more stable and independent of the object surface properties.
The camera is built around the monochrome CMOS image sensor A1024B, developed by Photonfocus. The principal advantages are:

- High reliability of 3D reconstruction, due to the non-linear interpolation technique used in the peak detection algorithm
- Peak detection with up to 1/64 subpixel accuracy
- Less post-processing necessary for obtaining perfectly smooth surfaces
- Extremely high image contrast achieved by LinLog®technology
- Stabilization of laser triangulation applications independent from object surfaces
- Detection of small features on the inspected parts due to decreased noise sensitivity
- Combined 2D/3D applications can be realized in the 2D/3D mode of the camera
- Global shutter
- Region of interest (ROI) freely selectable in x and y direction
- Stabilization of laser triangulation applications independent from object surfaces
- Detection of small features on the inspected parts due to decreased noise sensitivity
- Several simultaneously selectable read out windows: Multiple region of interest (Multiple ROI)
- The camera has a digital CameraLink® interface (CL base configuration)
- Grey level resolution up to 12 bit
- The compact size of only or 55 x 55 x 40 mm^3 make the MV-D1024E-3D01-160 camera the perfect solution for applications in which space is at a premium

The basic components for 3D imaging consist of a laser line and a high speed CMOS camera in a triangular arrangement to capture images (profiles) from objects that are moved on a conveyer belt or in a similar setup (see Fig. 3.1).

You can find more information on the basics of laser triangulation and on the principles of 3D image acquisition technique in the user manual "PF 3D Suite" available in the support area at www.photonfocus.com.

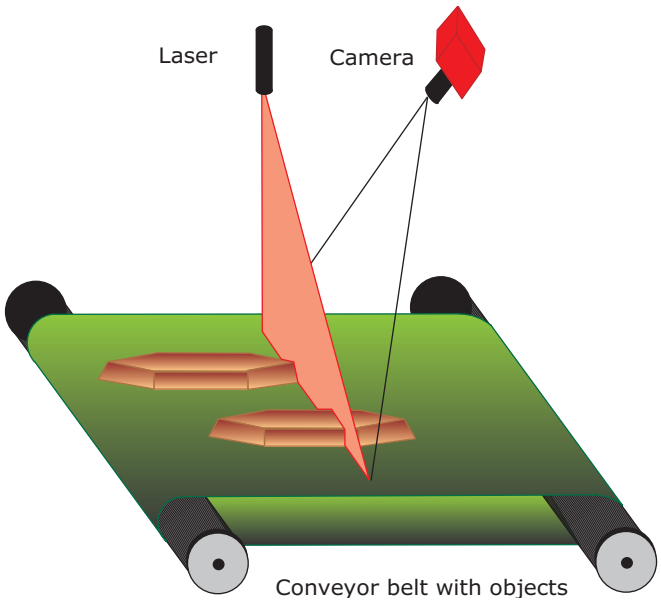

Figure 3.1: Triangulation principle with objects moved on a conveyor belt

3.2 Feature Overview

The general specification and features of the camera are listed in the following sections. The detailed description of the camera features is given in Chapter 4.

	MV-D1024E-3D01-160
Interfaces	CameraLink base configuration
Camera Control	PFRemote (Windows GUI) or programming library
Configuration Interface	serial, 9‘600 baud or 57.6 kbaud (user selectable)
Trigger Modes	Interface Trigger / I/O Trigger
Exposure Time	Defined by camera or trigger pulse width
Features	3D Peak Detector
	Linear Mode / LinLog®Mode / Skimming
	Shading Correction (Offset and Gain)
	Grey level resolution 12 bit / 10 bit / 8 bit
	Region of Interest (ROI) / Multiple Regions of Interest (MROI)
	Look-up table (10 to 8 bit) / Decimation
	Trigger input / Strobe output with programmable delay
	Test pattern / Image information / Status line

Table 3.1: Feature overview (see Chapter 4 for more information)

3.3 Technical Specification

	MV-D1024E-3D01-160
Sensor	A1024B Photonfocus
Technology	CMOS active pixel
Scanning system	progressive scan
Optical format / diagonal	1” / 15.42 mm
Resolution	1024 x 1024 pixels
Pixel size	10.6 μm x 10.6 μm
Active optical area	10.9 mm x 10.9 mm
Random noise	< 0.5 DN RMS @ 8 bit / gain= 1
Fixed pattern noise (FPN)	< 1 DN RMS @ 8 bit / gain= 1 / offset correction on
Dark current	2 fA/pixel @ 30°C
Full well capacity	200 ke$^-$
Spectral range	400 nm ... 900 nm
Responsivity	120 x 10^3 DN / (J/m^2) @ 610 nm / 8 bit / gain = 1
Optical fill factor	35%
Dynamic range	up to 120 dB (with LinLog®)
Colour format	monochrome
Characteristic curve	Linear, LinLog®, Skimming
Shutter mode	global shutter
Minimum Region of Interest (ROI)	1 row x 9 columns
Greyscale Resolution	12 bit / 10 bit / 8 bit
Digital Gain	x1 / x2 / x4
Exposure Time	10 μs ... 0.41 s

Table 3.2: General specification of the MV-D1024E-3D01-160 camera

	MV-D1024E-3D01-160
Exposure Time Increment	25 ns
Frame Rate (T_{int} = 10 μs)	150 fps
Pixel Clock Frequency	80 MHz
Pixel Clock Cycle	25 ns
Camera Taps	2
Readout mode	sequential or simultaneous

Table 3.3: Model-specific parameters

	MV-D1024E-3D01-160
Operating temperature	0°C ... 50°C
Camera power supply	+12 V DC (±10%)
Trigger signal input range	+5 .. +15 V DC
Strobe signal power supply	+5 .. +15 V DC
Strobe signal sink current (average)	max. 8 mA
Maximum power consumption	3.7 W
Lens mount	C- or CS-Mount
Dimensions	55 x 55 x 40 mm^3
Mass	210 g
Conformity	CE, RoHS, WEEE

Table 3.4: Physical characteristics and operating ranges

Fig. 3.2 shows the quantum efficiency curve of the A1024B sensor from Photonfocus measured in the wavelength range from 250 nm to 1100 nm. Note, that the oscillations in the diagram are caused by the multilayer interferences of the sensor.

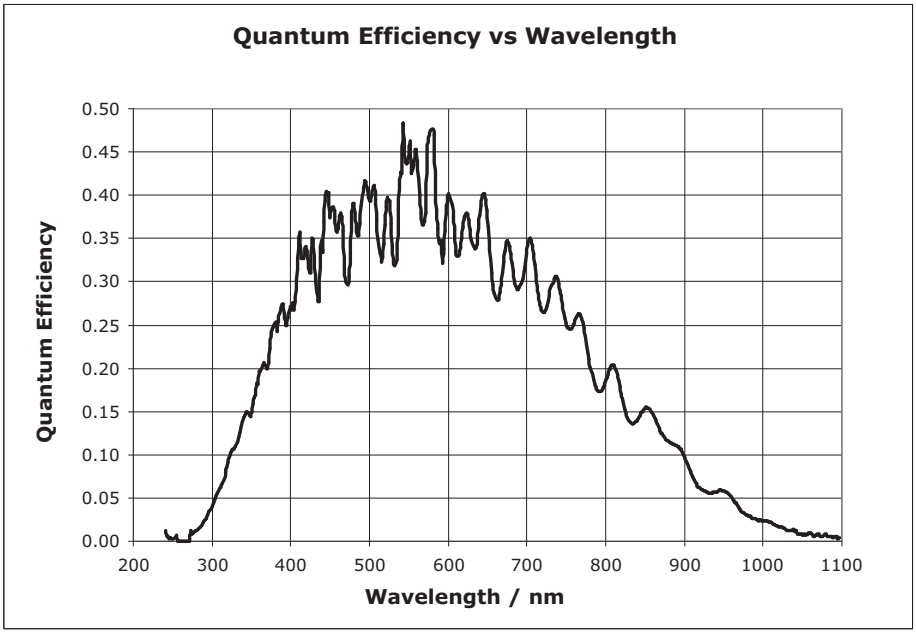

Figure 3.2: Spectral response of the A1024B CMOS sensor from Photonfocus

3.4 Frame Grabber relevant Configuration

Table 3.5 summarizes the parameters needed for the configuration of the frame grabber.

	MV-D1024E-3D01-160
Pixel Clock per Tap	80 MHz
Number of Taps	2
Greyscale resolution	12 bit / 10 bit / 8 bit
CC1	EXSYNC
CC2	not used
CC3	not used
CC4	not used

Table 3.5: Summary of parameters needed for frame grabber configuration

CameraLink Port and Bit assignments are compliant to the CameraLink standard (see [CL]).

Bit	Tap 0	Tap 1	Tap 0	Tap 1	Tap 0	Tap 1
	8 Bit	8 Bit	10 Bit	10 Bit	12 Bit	12 Bit
0 (LSB)	A0	B0	A0	C0	A0	C0
1	A1	B1	A1	C1	A1	C1
2	A2	B2	A2	C2	A2	C2
3	A3	B3	A3	C3	A3	C3
4	A4	B4	A4	C4	A4	C4
5	A5	B5	A5	C5	A5	C5
6	A6	B6	A6	C6	A6	C6
7 (MSB of 8 Bit)	A7	B7	A7	C7	A7	C7
8	-	-	B0	B4	B0	B4
9 (MSB of 10 Bit)	-	-	B1	B5	B1	B5
10	-	-	-	-	B2	B6
11 (MSB of 12 Bit)	-	-	-	-	B3	B7

Table 3.6: CameraLink® CameraLink port and bit assignments for the MV-D1024E-3D01-160 camera

The output of grey values is listed in Table 3.6. 3D data are assigned in the bits [7:0]. For further information see Section 4.8.3.

4

Functionality

This chapter serves as an overview of the camera configuration modes and explains camera features. The goal is to describe what can be done with the camera. The setup of the camera is explained in later chapters.

4.1 Image Acquisition

4.1.1 Readout Modes

The MV-D1024E-3D01-160 camera provides two different readout modes:

Sequential readout:

Frame time is the sum of exposure time and readout time. Exposure time of the next image can only start if the readout time of the current image is finished.

Simultaneous readout (interleave):

The frame time is determined by the maximum of the exposure time or of the readout time, which ever of both is the longer one. Exposure time of the next image can start during the readout time of the current image.

	MV-D1024E-3D01-160
Sequential readout	available
Simultaneous readout	available

Table 4.1: Readout modes of the MV-D1024E-3D01-160 camera

Fig. 4.1 illustrates the effect on the frame rate when using either the sequential readout mode or the simultaneous readout mode (interleave exposure).

Sequential readout mode:

For the calculation of the frame rate only a single formula applies: frames per second equal to the invers of the sum of exposure time and readout time.

Simultaneous readout mode (exposure time < readout time):

The frame rate is given by the readout time. Frames per second equal to the invers of the readout time.

Simultaneous readout mode (exposure time > readout time):

The frame rate is given by the exposure time. Frames per second equal to the invers of the exposure time.
The simultaneous readout mode allows to achieve a higher frame rate. However, if the exposure time strongly exceeds the readout time, then the effect on the frame rate is neglectable.

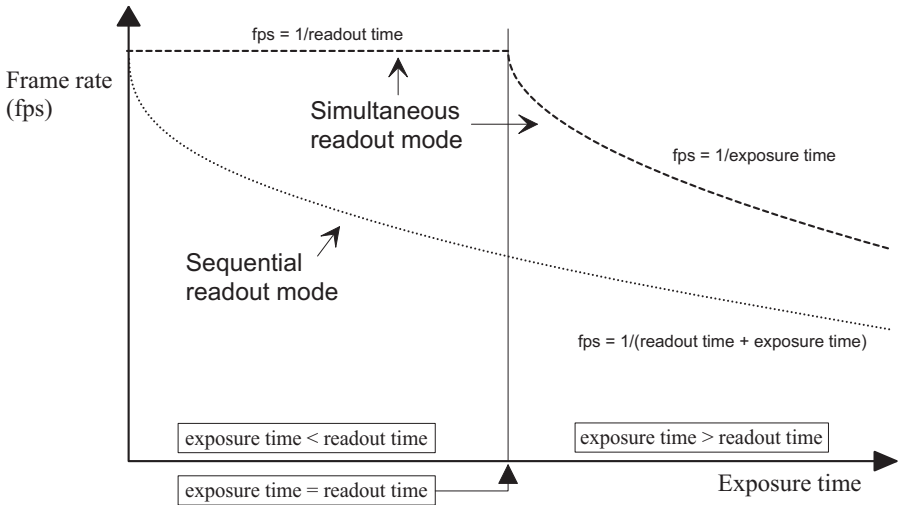

Figure 4.1: Frame rate in sequential readout mode and simultaneous readout mode

In simultaneous readout mode image output faces minor limitations. The overall linear sensor reponse is partially restricted in the lower grey scale region.

When changing readout mode from sequential to simultaneous readout mode or vice versa, new settings of the BlackLevelOffset and of the image correction are required.

Sequential readout:

By default the camera continuously delivers images as fast as possible ("Free-running mode") in the sequential readout mode. Exposure time of the next image can only start if the readout time of the current image is finished.

Figure 4.2: Timing in free-running sequential readout mode

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 4.6 and Section 5.4). In this mode, the camera is idle until it gets a signal to capture an image.

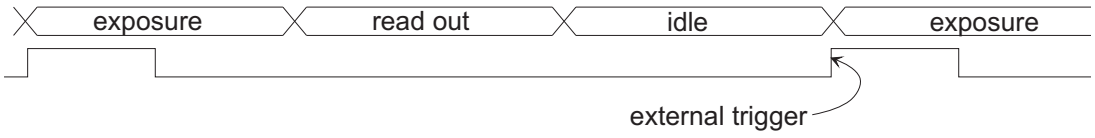

Figure 4.3: Timing in triggered sequential readout mode

Simultaneous readout (interleave exposure):

To achieve highest possible frame rates, the camera must be set to "Free-running mode" with simultaneous readout. The camera continuously delivers images as fast as possible. Exposure time of the next image can start during the readout time of the current image.

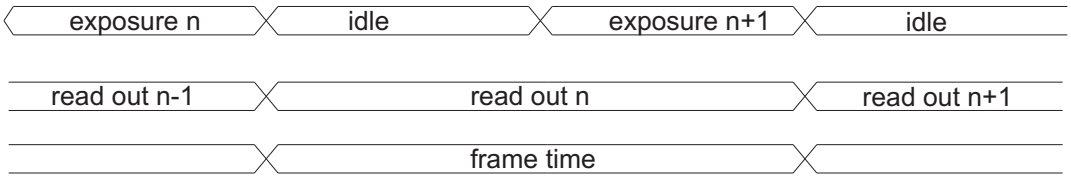

Figure 4.4: Timing in free-running simultaneous readout mode (readout time > exposure time)

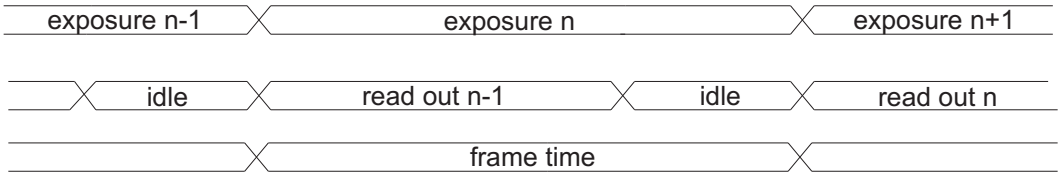

Figure 4.5: Timing in free-running simultaneous readout mode (readout time < exposure time)

When the acquisition of an image needs to be synchronised to an external event, an external trigger can be used (refer to Section 4.6 and Section 5.4). In this mode, the camera is idle until it gets a signal to capture an image.

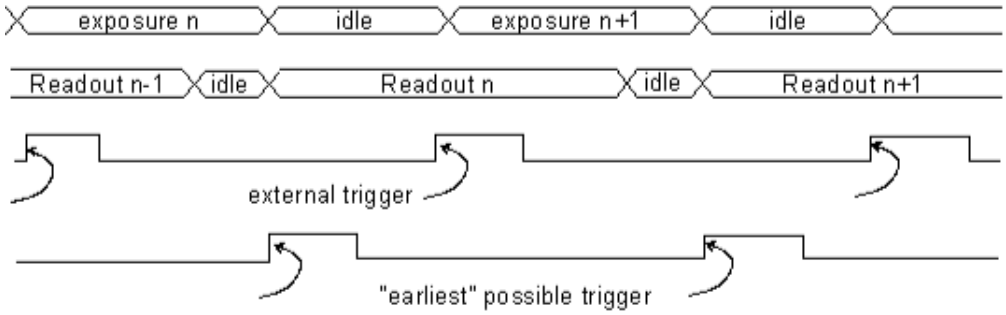

Figure 4.6: Timing in triggered simultaneous readout mode

4.1.2 Exposure Control

The exposure time defines the period during which the image sensor integrates the incoming light. Refer to Table 3.3 for the allowed exposure time range and see Section 5.4.1

4.1.3 Maximum Frame Rate

The maximum frame rate depends on the exposure time, the readout scheme and the size of the image (see Region of Interest, Section 4.5.1). In most cases, simultaneous readout is best choice for highest framerate.

Skimming is not supported in simultaneous readout mode.

4.1.4 Constant Frame Rate (CFR)

When the CFR mode is switched on, the frame rate (number of frames per second) can be varied from almost 0 up to the maximum frame rate. Thus, fewer images can be acquired than would otherwise be possible.
When Constant Frame Rate is switched off, the camera delivers images as fast as possible, depending on the exposure time and the read-out time. See Section 5.3.2 for more information.

Constant Frame Rate mode (CFR) is not available together with external trigger mode.

4.2 Image Information

There are camera properties available that give information about the acquired images, such as an image counter, average image value and the number of missed trigger signals. These properties can be queried by software. Alternatively, a status line within the image data can be switched on that contains all the available image information.

4.2.1 Counters and Average Value

Image counter:

The image counter provides a sequential number of every image that is output. After camera startup, the counter counts up from 0 (counter width 24 bit). The counter can be reset by the camera control software.

Missed trigger counter:

The missed trigger counter counts trigger pulses that were ignored by the camera because they occurred within the exposure or read-out time of an image. In free-running mode it counts all incoming external triggers (counter width 8 bit / no wrap around).

Average image value:

The average image value gives the average of an image in 12 bit format (0 .. 4095 DN), regardless of the currently used grey level resolution.

4.2.2 Status Line

If enabled, the status line replaces the last row of the image with image information. It contains the properties described above and additional information. Every parameter is coded into 4 pixels (LSB first) and uses the lower 8 bits of the pixel value, so that the total size of a parameter is 32 bit. The remaining pixels (24..1024) are set to 0.

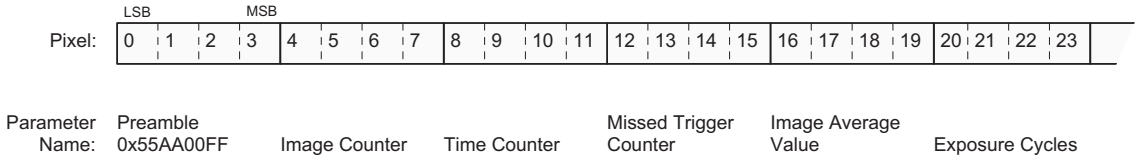

Figure 4.7: Status line parameters replace the last row of the image

The status line is also available when using an ROI. For an ROI with a width <24 pixels, the status line will be clipped.

The first two data fields of the status line (preamble and image counter) are also transmitted on the 3D data (in either of the output modes "2D and 3D" or "3D").

Preamble:

The first parameter contains a constant value of 0x55AA00FF as a preamble in order to allow the image processing system to easily recognise the beginning of the status line.

Image counter:

See Section 4.2.1.

Time counter:

The time counter starts at 0 after camera start, and counts real-time in units of 1 micro-second. The time counter can be reset by the software in the SDK (Counter width 32 bit).

Missed trigger counter:

See Section 4.2.1.

Average image value:

See Section 4.2.1.

Exposure cycles:

The exposure cycles parameter outputs the current exposure time in units of clock cycles (see Table 3.3).

4.3 Pixel Response

4.3.1 Linear Response

The camera offers a linear response between input light signal and output grey level. This can be modified by the use of LinLog®or Skimming as described in the following sections. In addition, a linear digital gain may be applied, as follows. Please see Table 3.2 for more model-dependent information.

Gain x1, x2, x4

Gain x1, x2 and x4 are digital amplifications, which means that the digital image data are multiplied in the camera by a factor 1, 2 or 4, respectively.

Black Level Adjustment

The black level is the average image value at no light intensity. It can be adjusted by the software by changing the black level offset. Thus, the overall image gets brighter or darker. Use a histogram to control the settings of the black level.

4.3.2 LinLog®

Overview

The LinLog® technology from Photonfocus allows a logarithmic compression of high light intensities inside the pixel. In contrast to the classical non-integrating logarithmic pixel, the LinLog® pixel is an integrating pixel with global shutter and the possibility to control the transition between linear and logarithmic mode.
In situations involving high intrascene contrast, a compression of the upper grey level region can be achieved with the LinLog® technology. At low intensities each pixel shows a linear response. At high intensities the response changes to logarithmic compression (see Fig. 4.8). The transition region between linear and logarithmic response can be smoothly adjusted by software and is continuously differentiable and monotonic.

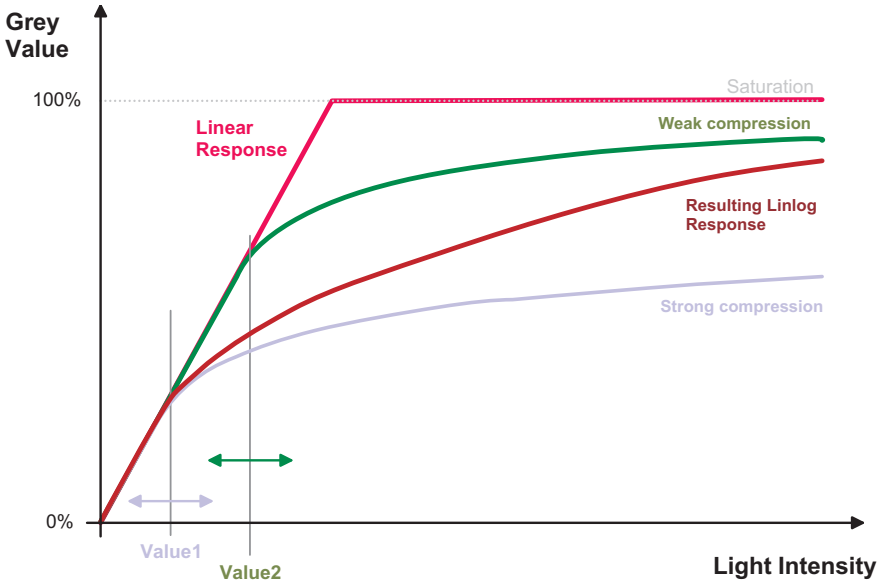

Figure 4.8: Resulting LinLog2 response curve

LinLog® is controlled by up to 4 parameters (`Time1`, `Time2`, `Value1` and `Value2`). `Value1` and `Value2` correspond to the LinLog® voltage that is applied to the sensor. The higher the parameters `Value1` and `Value2` respectively, the stronger the compression for the high light intensities. `Time1` and `Time2` are normalised to the exposure time. They can be set to a maximum value of 1000, which corresponds to the exposure time.
Examples in the following sections illustrate the LinLog® feature.

LinLog1

In the simplest way the pixels are operated with a constant LinLog® voltage which defines the knee point of the transition.This procedure has the drawback that the linear response curve changes directly to a logarithmic curve leading to a poor grey resolution in the logarithmic region (see Fig. 4.10).

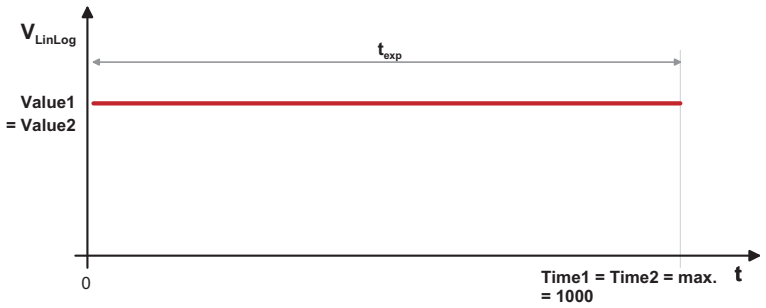

Figure 4.9: Constant LinLog voltage in the Linlog1 mode

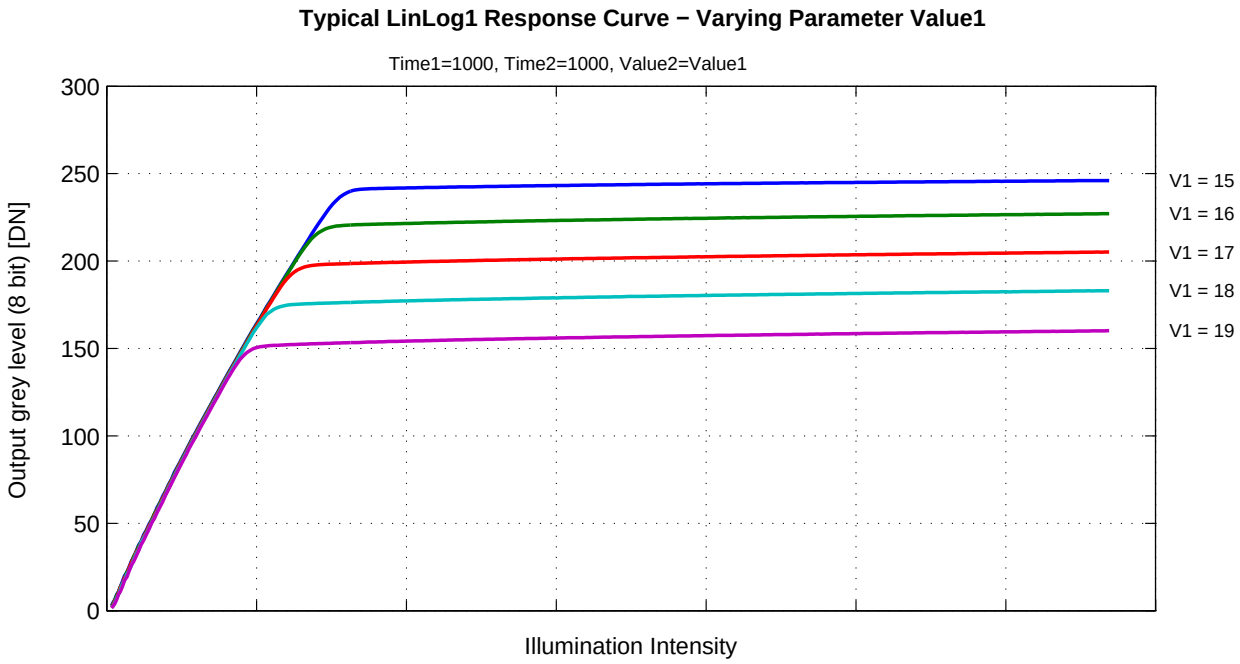

Figure 4.10: Response curve for different LinLog settings in LinLog1 mode

LinLog2

To get more grey resolution in the LinLog® mode, the LinLog2 procedure was developed. In LinLog2 mode a switching between two different logarithmic compressions occurs during the exposure time (see Fig. 4.11). The exposure starts with strong compression with a high LinLog®voltage (`Value1`). At `Time1` the LinLog®voltage is switched to a lower voltage resulting in a weaker compression. This procedure gives a LinLog®response curve with more grey resolution. Fig. 4.12 and Fig. 4.13 show how the response curve is controlled by the three parameters `Value1`, `Value2` and the LinLog®time `Time1`.

Settings in LinLog2 mode, enable a fine tuning of the slope in the logarithmic region.

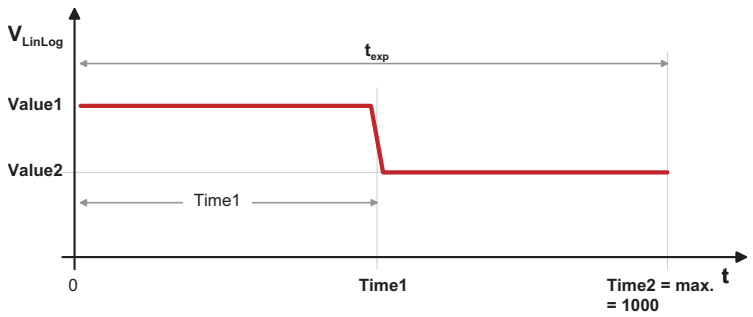

Figure 4.11: Voltage switching in the Linlog2 mode

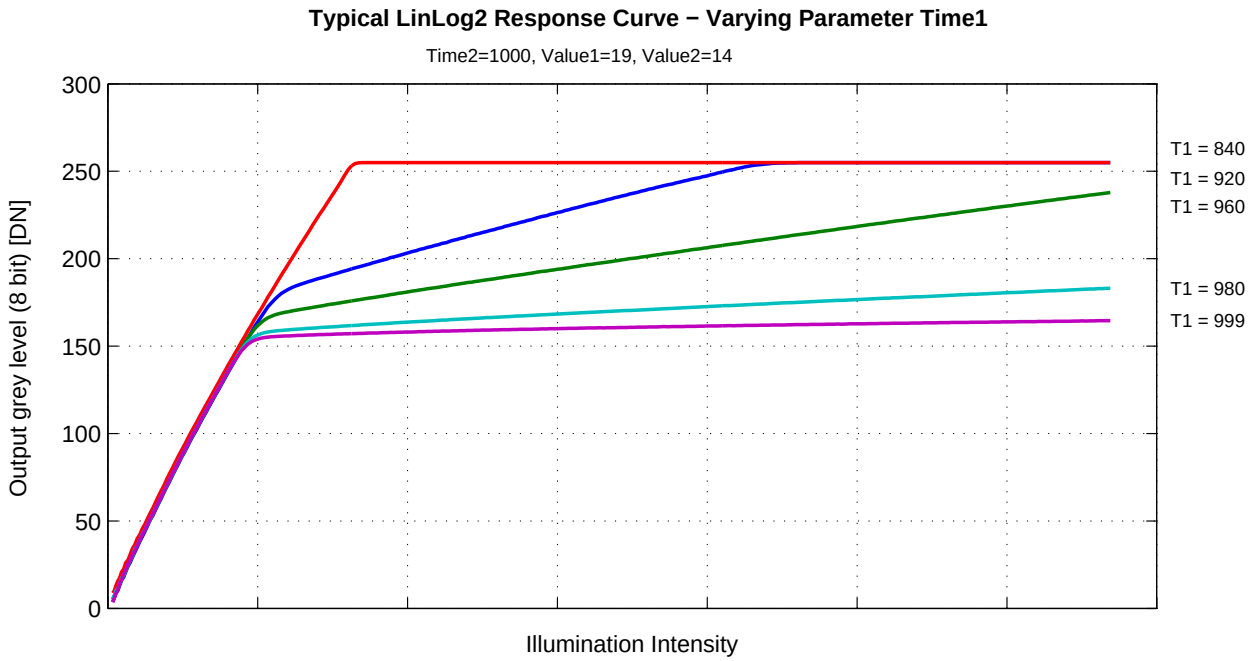

Figure 4.12: Response curve for different LinLog settings in LinLog2 mode

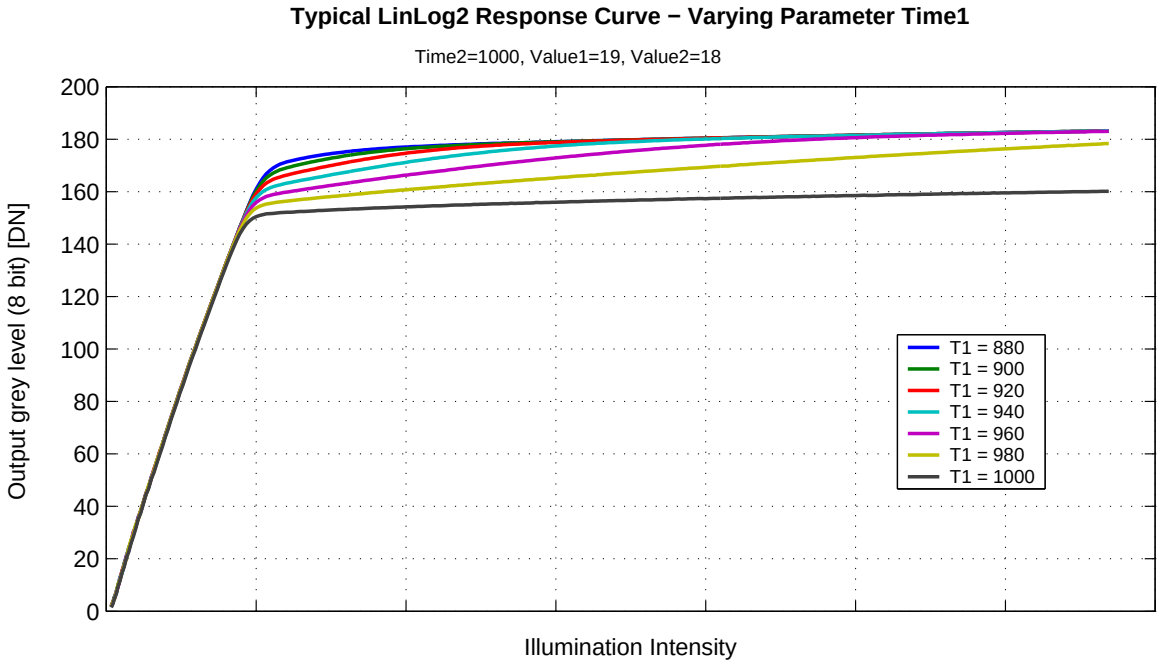

Figure 4.13: Response curve for different LinLog settings in LinLog2 mode

LinLog3

To enable more flexibility the LinLog3 mode with 4 parameters was introduced. Fig. 4.14 shows the timing diagram for the LinLog3 mode and the control parameters.

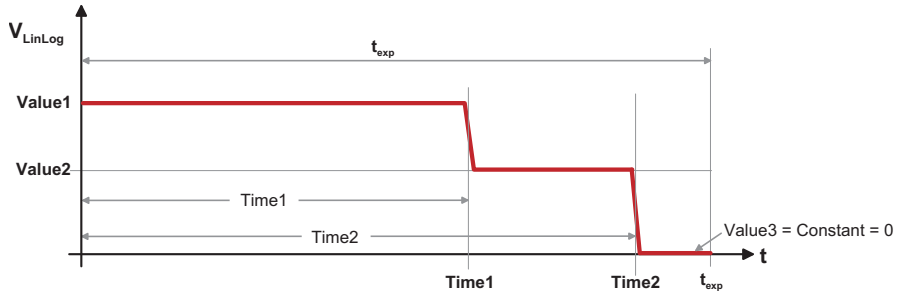

Figure 4.14: Voltage switching in the LinLog3 mode

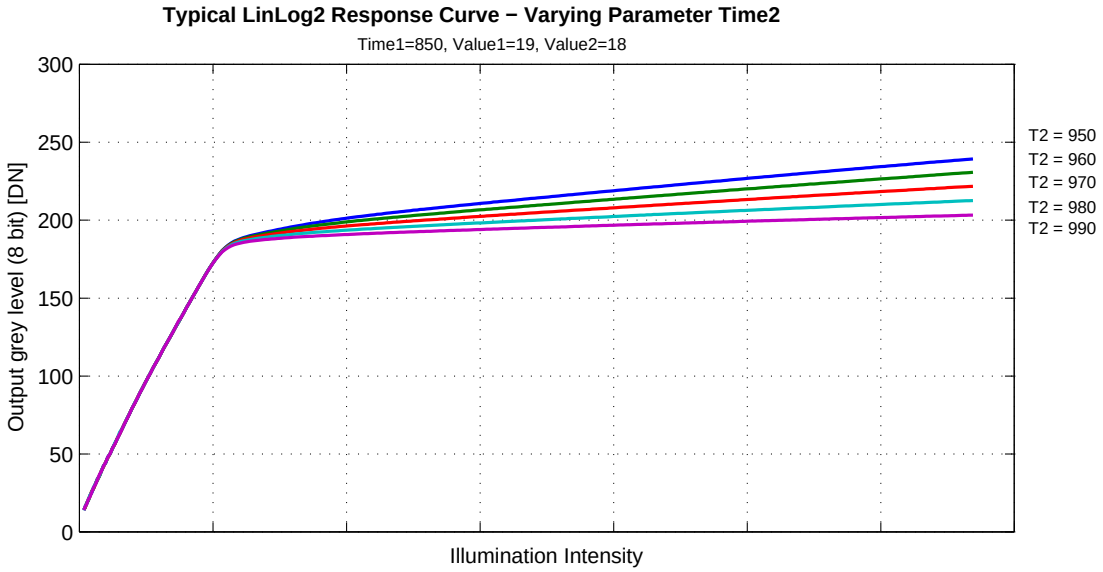

Figure 4.15: Response curve for different LinLog settings in LinLog3 mode

4.3.3 Skimming

Skimming is a Photonfocus proprietary technology to enhance detail in dark areas of an image. Skimming provides an adjustable level of in-pixel gain for low signal levels. It can be used together with LinLog®to give a smooth monotonic transfer function from high gain at low levels, through normal linear operation, to logarithmic compression for high signal levels (see Fig. 4.16). The resulting response is similar to a gamma correction.

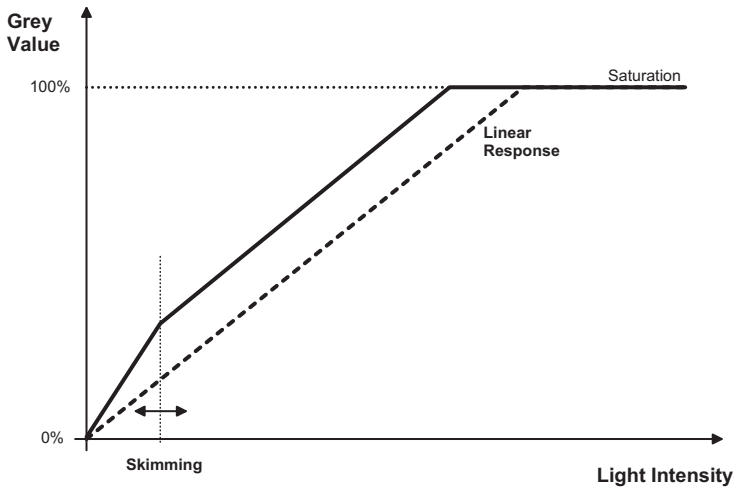

Figure 4.16: Response curve for different skimming settings

4.3.4 Grey Level Transformation (LUT)

Grey level transformation is remapping of the grey level values of an input image to new values. The look-up table (LUT) is used to convert the greyscale value of each pixel in an image into another grey value. It is typically used to implement a transfer curve for contrast expansion. The camera performs a 10-to-8-bit mapping, so that 1024 input grey levels can be mapped to 256 output grey levels. The use of the three available modes is explained in the next sections.

The output grey level resolution of the look-up table (independent of gain, gamma or user-definded mode) is always 8 bit.

There are 2 predefined functions, which generate a look-up table and transfer it to the camera. For other transfer functions the user can define his own LUT file.

Gain

The ‘Gain’ mode performs a digital, linear amplification (see Fig. 4.17). It is configurable in the range from 1.0 to 4.0 (e.g. 1.234).

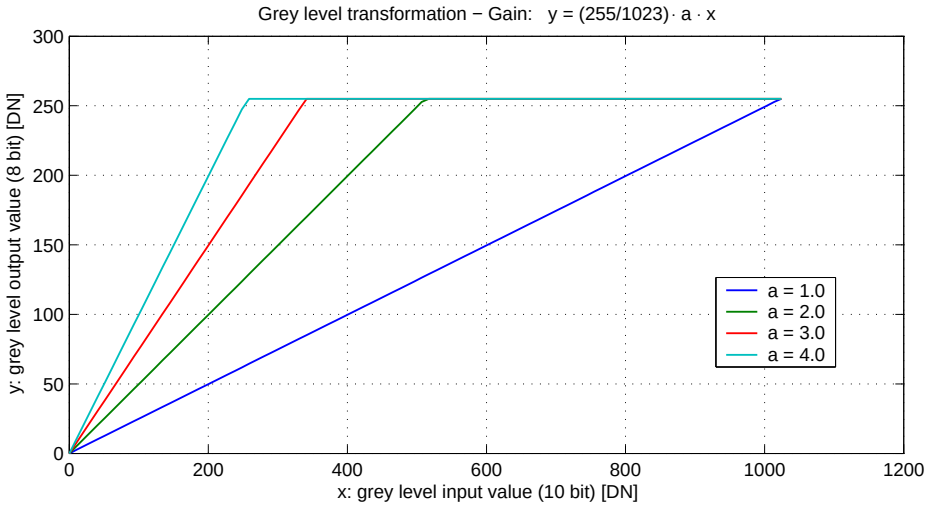

Figure 4.17: Applying a linear gain to an image

Gamma

The ‘Gamma’ mode performs an exponential amplification, configurable in the range from 0.4 to 4.0. Gamma > 1.0 results in an attenuation of the image (see Fig. 4.18), gamma < 1.0 results in an amplification (see Fig. 4.19).

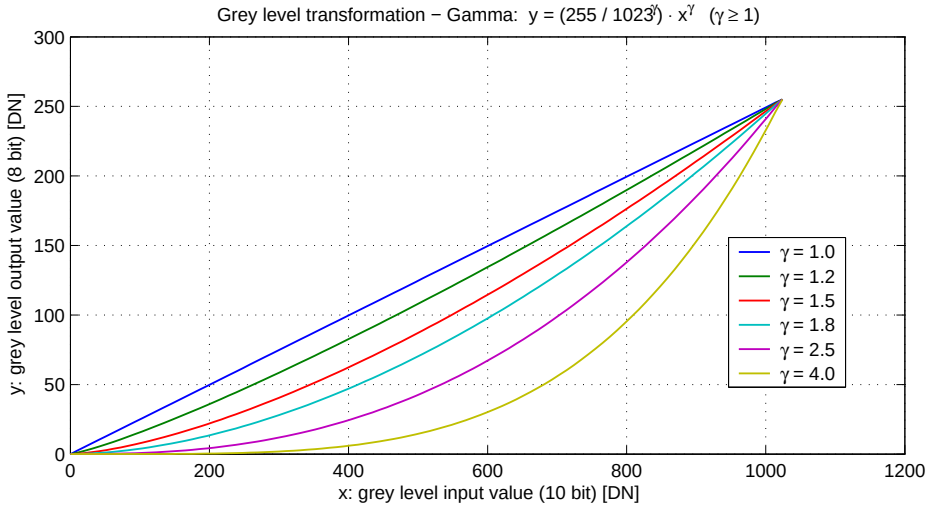

Figure 4.18: Applying gamma correction to an image (gamma > 1)

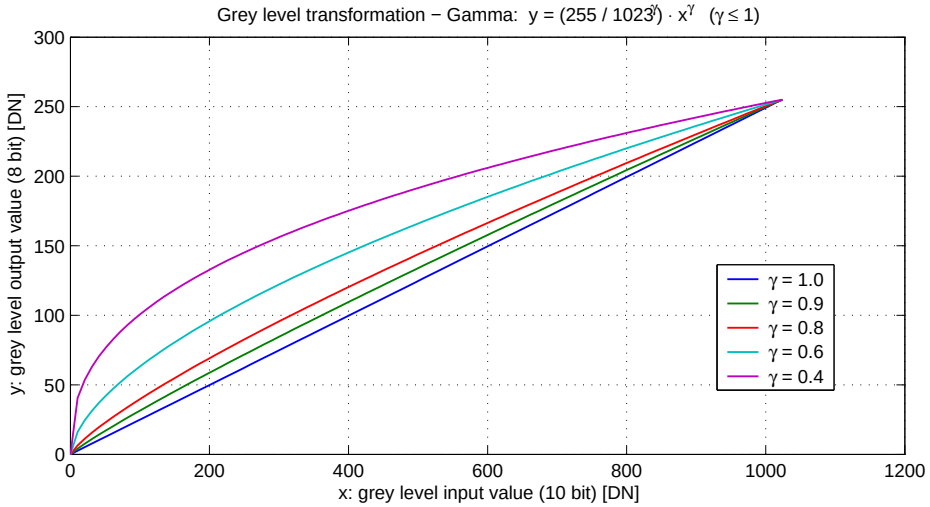

Figure 4.19: Applying gamma correction to an image (gamma < 1)

User-defined Look-up Table

In the 'User' mode, the mapping of input to output grey levels can be configured arbitrarily by the user. There is an example file in the PFRemote folder.

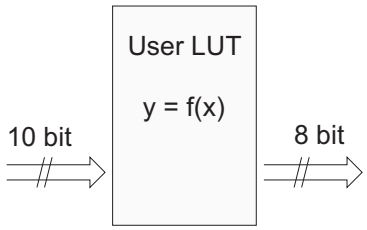

Figure 4.20: Data path through LUT

4.3.5 Test Images

Test images are generated in the camera FPGA, independent of the image sensor. They can be used to check the transmission path from the camera to the frame grabber. Independent from the configured grey level resolution, every possible grey level appears the same number of times in a test image. Therefore, the histogram of the received image must be flat.

A test image is a useful tool to find data transmission errors that are caused most often by a defective cable between camera and frame grabber.

Test images give the correct result at full resolution only.

Ramp

Depending on the configured grey level resolution, the ramp test image outputs a constant pattern with increasing grey level from the left to the right side (see Fig. 4.21).

Figure 4.21: Ramp test images: 8 bit output (left), 10 bit output (middle), 12 bit output (right)

LFSR

The LFSR (linear feedback shift register) test image outputs a constant pattern with a pseudo-random grey level sequence containing every possible grey level that is repeated for every row. In 12 bit mode only a fourth of all possible grey values appear.

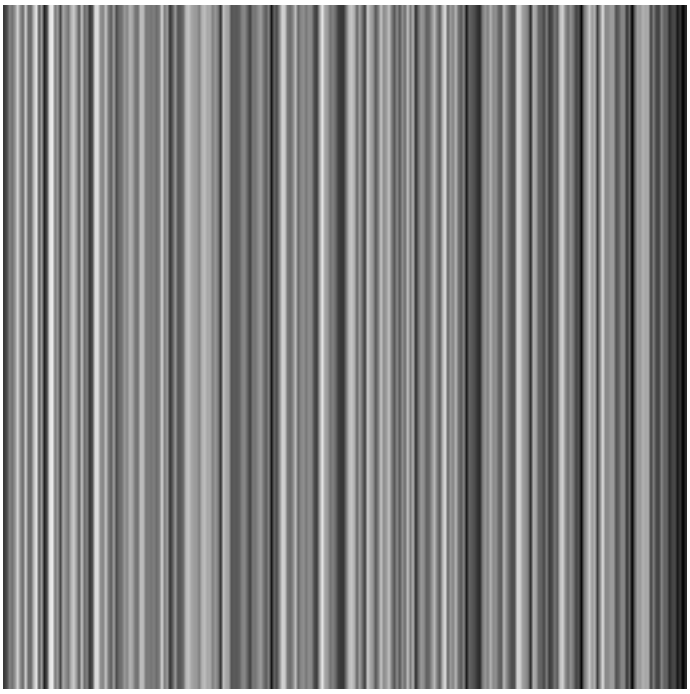

Figure 4.22: LFSR test image

In the histogram you can see that the number of pixels of all grey values are the same. Please refer to application note [AN026] for the calculation and the values of the LFSR test image.

Troubleshooting using the LFSR

To control the quality of your complete imaging system enable the LFSR mode and check the histogram. If your frame grabber application does not provide a real-time histogram, store the image and use a graphics software to display the histogram.
In the LFSR (linear feedback shift register) mode the camera generates a constant test pattern containing all grey levels. If the data transmission is error free, the histogram of the received LFSR test pattern will be flat (Fig. 4.23). On the other hand, a non-flat histogram (Fig. 4.24) indicates problems, that may be caused either by the cable, the connectors or the frame grabber.

A possible origin of failure message can be caused by the CameraLink cable which exceeds the maximum length or suffers from severe electromagnetic interference.

Some CameraLink cable have predefined direction.

The LFSR test works only for an image width of 1024, otherwise the histogram will not be flat.

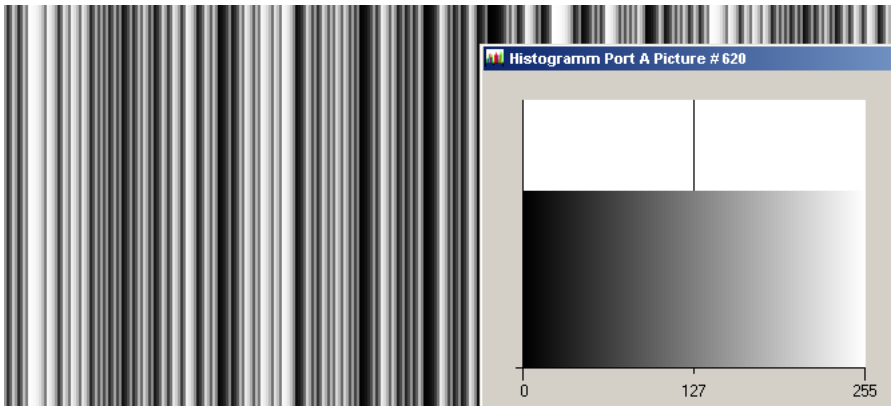

Figure 4.23: LFSR test pattern received at the frame grabber and typical histogram for error-free data transmission

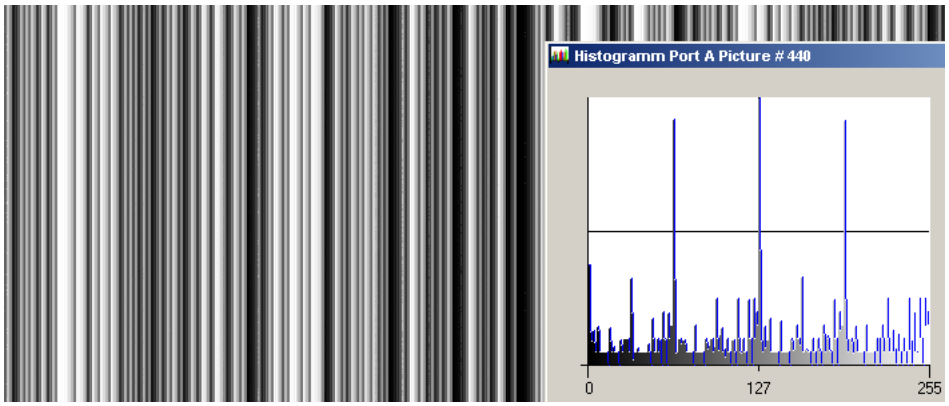

Figure 4.24: LFSR test pattern received at the frame grabber and histogram containing transmission errors

CameraLink cables contain wire pairs, which are twisted in such a way that the cable impedance matches with the LVDS driver and receiver impedance. Excess stress on the cable results in transmission errors which causes distorted images. Therefore, please do not stretch and bend a CameraLink cable.

In robots applications, the stress that is applied to the CameraLink cable is especially high due to the fast movement of the robot arm. For such applications, special drag chain capable cables are available.

4.4 Image Correction

4.4.1 Overview

The MV-D1024E-3D01-160 camera possesses image pre-processing features, that compensate for non-uniformities caused by the sensor, the lens or the illumination. This method of improving the image quality is generally known as 'Shading Correction' or 'Flat Field Correction' and consists of a combination of offset correction, gain correction and pixel interpolation.

Since the correction is performed in hardware, there is no performance limitation for high frame rates.

The offset correction subtracts a configurable positive or negative value from the live image and thus reduces the fixed pattern noise of the CMOS sensor. In addition, hot pixels can be removed by interpolation. The gain correction can be used to flatten uneven illumination or to compensate shading effects of a lens. Both offset and gain correction work on a pixel-per-pixel basis, i.e. every pixel is corrected separately. For the correction, a black reference and a grey reference image are required. Then, the correction values are determined automatically in the camera.

Do not set any reference images when gain or LUT is enabled!

Correction values of both reference images can be saved into the internal flash memory, but this overwrites the factory presets. Then the reference images that are delivered by factory cannot be restored anymore.

4.4.2 Offset Correction (FPN, Hot Pixels)

The offset correction is based on a black reference image, which is taken at no illumination (e.g. lens aperture completely closed). The black reference image contains the fixed-pattern noise of the sensor, which can be subtracted from the live images in order to minimise the static noise.

Offset correction algorithm

After configuring the camera with a black reference image, the camera is ready to apply the offset correction:

1. Determine the average value of the black reference image.
2. Subtract the black reference image from the average value.
3. Mark pixels that have a grey level higher than 1008 DN (@ 12 bit) as hot pixels.
4. Store the result in the camera as the offset correction matrix.
5. During image acquisition, subtract the correction matrix from the acquired image and interpolate the hot pixels (see Section 4.4.2).

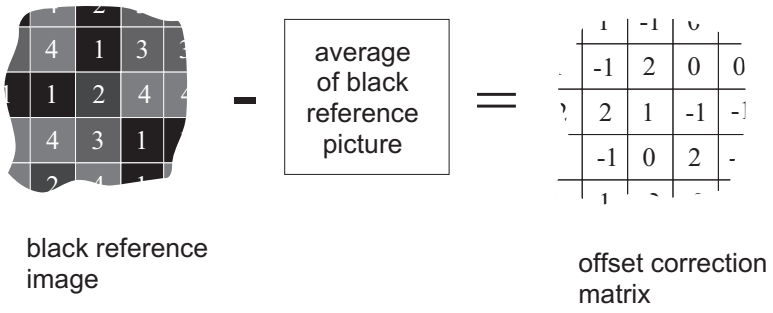

Figure 4.25: Offset correction

How to Obtain a Black Reference Image

In order to improve the image quality, the black reference image must meet certain demands.

The detailed procedure to set the black reference image is described in Section 7.1.7.

- The black reference image must be obtained at no illumination, e.g. with lens aperture closed or closed lens opening.
- It may be necessary to adjust the black level offset of the camera. In the histogram of the black reference image, ideally there are no grey levels at value 0 DN after adjustment of the black level offset. All pixels that are saturated black (0 DN) will not be properly corrected (see Fig. 4.26). The peak in the histogram should be well below the hot pixel threshold of 1008 DN @ 12 bit.
- Camera settings such as exposure time, LinLog®, skimming and digital gain may influence the grey level. Therefore, for best results the camera settings of the black reference image must be identical with the camera settings of the corrected image.

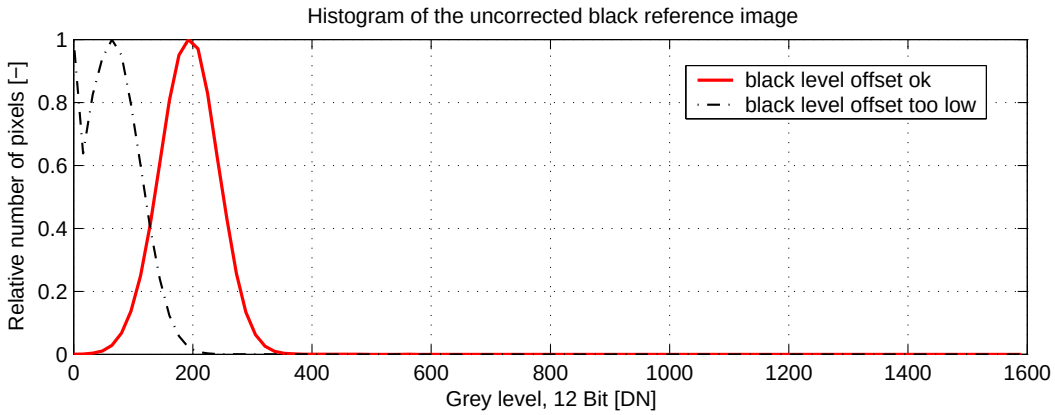

Figure 4.26: Histogram of a proper black reference image for offset correction

Hot pixel correction

Every pixel that exceeds a certain threshold in the black reference image is marked as a hot pixel. If the hot pixel correction is switched on, the camera replaces the value of a hot pixel by an average of its neighbour pixels (see Fig. 4.27).

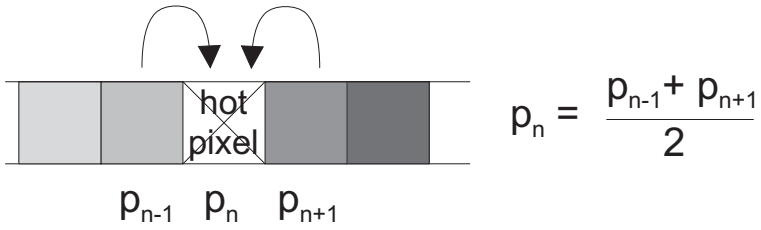

Figure 4.27: Hot pixel interpolation

4.4.3 Gain Correction

The gain correction is based on a grey reference image, which is taken at uniform illumination to give an image with a mid grey level.

Gain correction is not a trivial feature. The quality of the grey reference image is crucial for proper gain correction.

Gain correction algorithm

After configuring the camera with a black and grey reference image, the camera is ready to apply the gain correction:

1. Determine the average value of the grey reference image.
2. Subtract the offset correction matrix from the grey reference image.
3. Divide the average value by the offset corrected grey reference image.
4. Pixels that have a grey level bigger than a certain threshold are marked as hot pixels.
5. Store the result in the camera as the gain correction matrix.
6. During image acquisition, multiply the gain correction matrix from the offset-corrected acquired image and interpolate the hot pixels (see Section 4.4.2).

Gain correction always needs an offset correction matrix, so the offset correction has to be performed before the gain correction.

How to Obtain a Grey Reference Image

In order to improve the image quality, the grey reference image must meet certain demands.

The detailed procedure to set the grey reference image is described in Section 7.1.7.

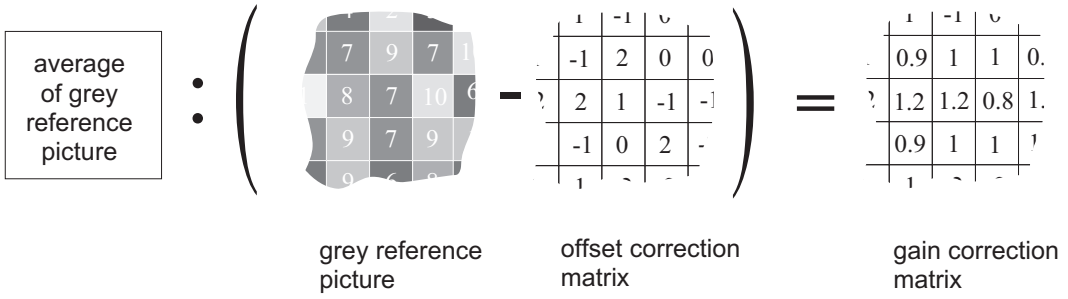

Figure 4.28: Gain Correction

- The grey reference image must be obtained at uniform illumination.

  Use a high quality light source that delivers uniform illumination. Standard illumination will not be appropriate.

- When looking at the histogram of the grey reference image, ideally there are no grey levels at full scale (4095 DN @ 12 bit). All pixels that are saturated white will not be properly corrected (see Fig. 4.29).
- Camera settings such as exposure time, LinLog, skimming and digital gain may influence the grey level. Therefore, the camera settings of the grey reference image must be identical with the camera settings of the corrected image.

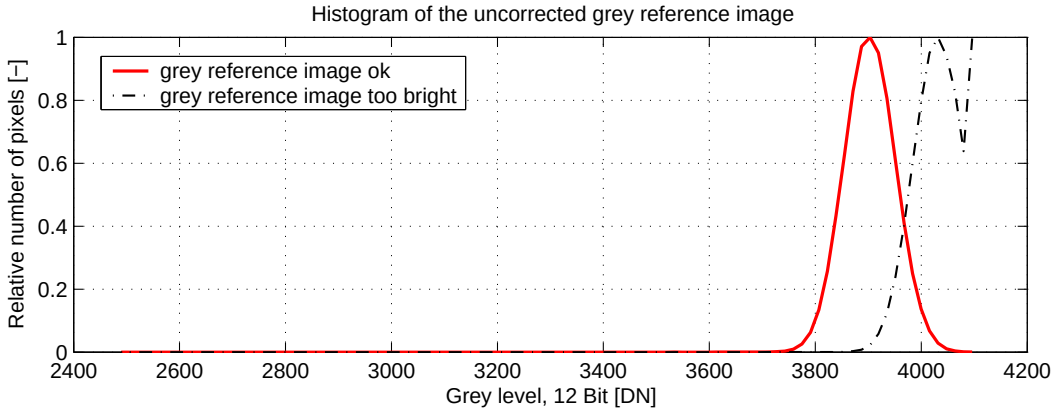

Figure 4.29: Proper grey reference image for gain correction

4.4.4 Corrected Image

Offset, gain and hot pixel correction can be switched on seperately. The following configurations are possible:

- No correction
- Offset correction only
- Offset and hot pixel correction
- Hot pixel correction only
- Offset and gain correction
- Offset, gain and hot pixel correction

In addition, the black reference image and grey reference image that are currently stored in the camera RAM can be output.

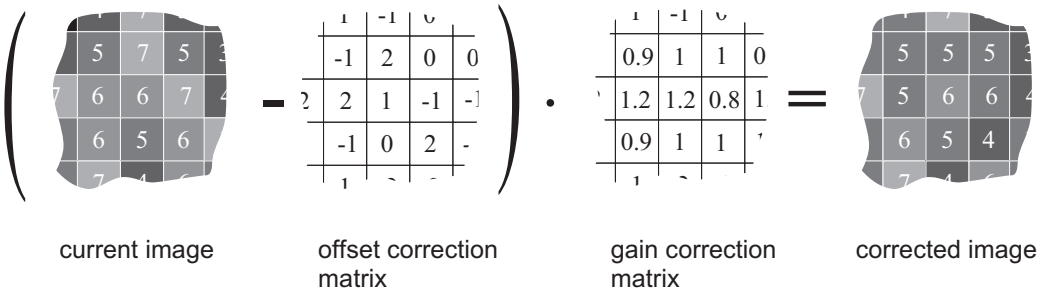

Figure 4.30: Corrected image

Table 4.2 shows the maximum values of the correction matrices, i.e. the error range that the offset and gain algorithm can correct.

	minimum	maximum
Offset correction	-508 DN @ 12 bit	+508 DN @ 12 bit
Gain correction	0.42	2.67

Table 4.2: Offset and gain correction ranges

4.5 Reduction of Image Size

With Photonfocus cameras there are several possibilities to focus on the interesting parts of an image, thus reducing the data rate and increasing the frame rate. The most commonly used feature is Region of Interest (ROI).

4.5.1 Region of Interest (ROI)

Some applications do not need full image resolution (e.g. 1024 x 1024 pixels). By reducing the image size to a certain region of interest (ROI), the frame rate can be drastically increased. A region of interest can be almost any rectangular window and is specified by its position within the full frame and its width and height. Fig. 4.31 gives some possible configurations for a region of interest, and Table 4.3 shows some numerical examples of how the frame rate can be increased by reducing the ROI.

To optimize the scan rate of the MV-D1024E-3D01-160 reduce the region of interest to the smallest possible setting (see Table 4.3).

Both reductions in x- and y-direction result in a higher frame rate.

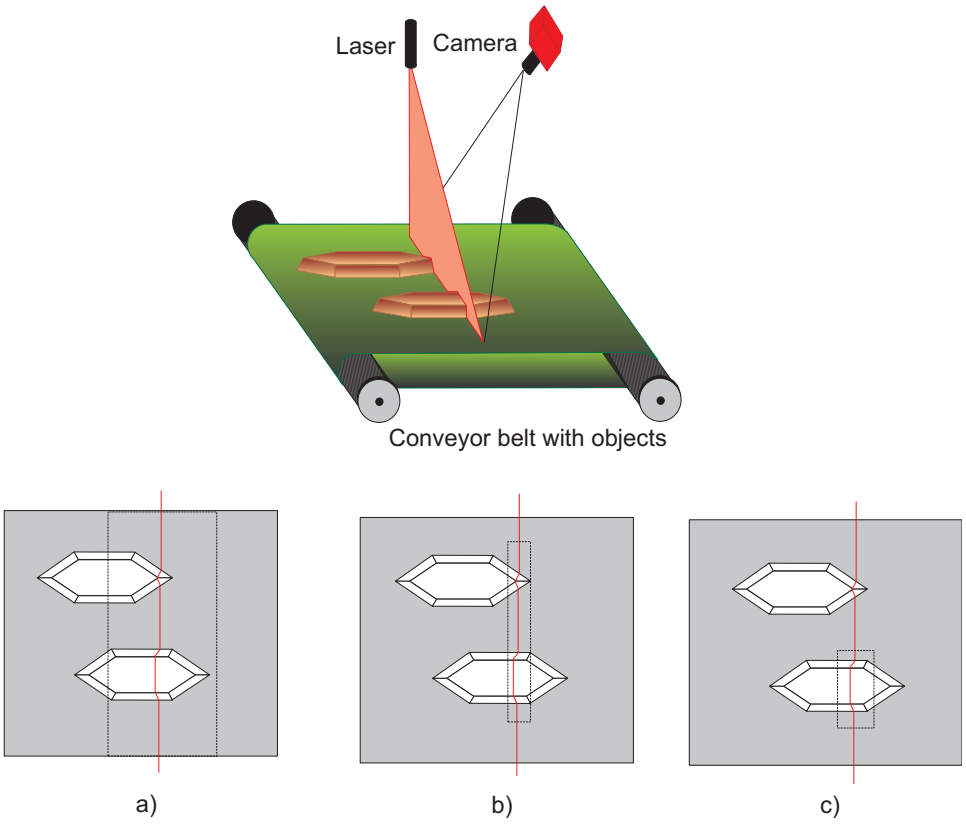

Figure 4.31: ROI configuration examples

ROI Dimension	Scan Rate
1024 x 1024	150 profiles / s
1024 x 512	290 profiles / s
1024 x 256	540 profiles / s
1024 x 128	980 profiles / s
1024 x 64	1630 profiles / s
1024 x 32	2445 profiles / s
512 x 512	560 profiles / s
512 x 256	1030 profiles / s
512 x 128	1775 profiles / s
512 x 64	2795 profiles / s
512 x 32	3915 profiles / s

Table 4.3: Scan rate of the MV-D1024E-3D01-160 at different ROI settings (exposure time 0.1 ms; CFR off, skimming off and sequential readout mode).

Exposure time	Sequential Readout	Simultaneous Readout
10 μs	1177 profiles / s	761 profiles / s
100 μs	1064 profiles / s	761 profiles / s
500 μs	746 profiles / s	761 profiles / s
1 ms	544 profiles / s	761 profiles / s
2 ms	352 profiles / s	482 profiles / s
5 ms	171 profiles / s	197 profiles / s
10 ms	92 profiles / s	99 profiles / s
12 ms	78 profiles / s	83 profiles / s

Table 4.4: Scan rate of the MV-D1024E-3D01-160 at different exposure times, in sequential readout mode and in simultaneous readout mode at 1024 x 128 pixel resolution (CFR off and skimming off).

Calculation of the maximum frame rate

The frame rate mainly depends of the exposure time and readout time. The frame rate is the inverse of the frame time. In the following formula the minimum frame time is calculated. When using CFR mode the frame time can get extended.

$$fps = \frac{1}{t_{frame}}$$

Calculation of the frame time (sequential mode)

$$t_{frame} \geq t_{exp} + t_{ro} + t_{proc} + t_{RAM}$$

Calculation of the frame time (simultaneous mode)

$$t_{frame} \geq \max(t_{exp} + 76\ \mu s,\ t_{ro} + 476\ \mu s) + t_{RAM}$$

$$t_{ro} = t_{CLK} * (P_y * (\frac{P_x}{taps} + LP) + LP)$$

$$t_{proc} = t_{Normal} + t_{CFR} + t_{FPN} + t_{Skim}$$

$$t_{RAM} = \frac{1}{128} * (t_{ro} + 1375\ ns) - (t_{exp} + t_{proc})$$

When the result of t_{RAM} is negative, set it to 0.

$\mathbf{t_{frame}}$ frame time
$\mathbf{t_{exp}}$ exposure time
$\mathbf{t_{ro}}$ readout time
$\mathbf{t_{proc}}$ processing time
$\mathbf{t_{RAM}}$ RAM refresh time
$\mathbf{t_{Normal}}$ constant latency
$\mathbf{t_{CFR}}$ constant frame rate latency, only when CFR is enabled
$\mathbf{t_{FPN}}$ correction latency, only when correction is enabled
$\mathbf{t_{Skim}}$ skim latency, only when Skimming is enabled
$\mathbf{t_{CLK}}$ pixel clock
taps CameraLink taps
$\mathbf{P_X}$ number of pixels in x-direction
$\mathbf{P_Y}$ number of pixels in y-direction (+1, for the MV-D1024E-3D01-160)
LP line pause, constant LP = 8 for all models

	MV-D1024E-3D01-160
t_{exp}	10 μs - 419 ms
t_{Normal}	1300 ns
t_{CFR}	0
t_{FPN}	0
t_{Skim}	50.8 μs
t_{CLK}	12.5 ns
taps	2
P_Y	Window H + 1

Table 4.5: Camera specific values for frame time calculations

A calculator for calculating the maximum frame rate is available in the support area of the Photonfocus website.

4.5.2 Multiple Regions of Interest

The MV-D1024E-3D01-160 camera can handle up to 16 different regions of interest. This feature can be used to reduce the image data and increase the frame rate. The multiple ROIs are joined together and form a single image, which is transferred to the frame grabber.
An ROI is defined by its starting value in y-direction and its height. Every ROI within a MROI must be of the same width. The maximum frame rate in MROI mode depends on the number of rows and columns being read out. Overlapping ROIs are allowed. See Section 4.5.1 for information on the calculation of the maximum frame rate.

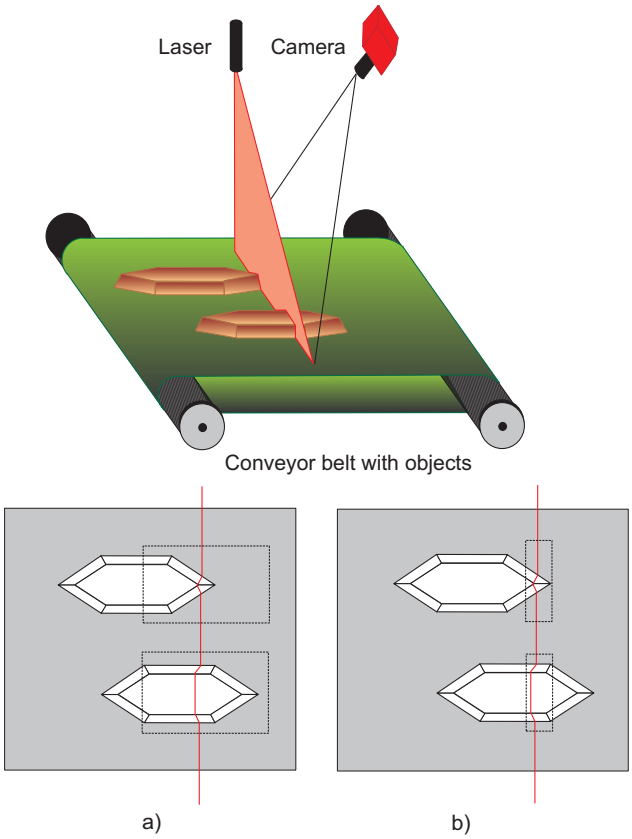

Figure 4.32: Multiple Regions of Interest with 2 ROIs

4.5.3 Decimation

Decimation reduces the number of pixels in y-direction. Decimation can also be used together with ROI or MROI. Decimation in y-direction transfers every n^{th} row only and directly results in reduced read-out time and higher frame rate respectively.

4.6 External Trigger

An external trigger is an event that starts an exposure. The trigger signal is either generated on the frame grabber (soft-trigger) or comes from an external device such as a light barrier. If a trigger signal is applied to the camera before the earliest time for the next trigger, this trigger will be ignored. The camera property `Counter.MissedTrigger` stores the number of trigger events which where ignored.

4.6.1 Trigger Source

The trigger signal can be configured to be active high or active low. One of the following trigger sources can be used:

Interface Trigger In the interface trigger mode, the trigger signal is applied to the camera by the CameraLink interface.

I/O Trigger In the I/O trigger mode, the trigger signal is applied directly to the camera by the power supply connector (over an optocoupler).

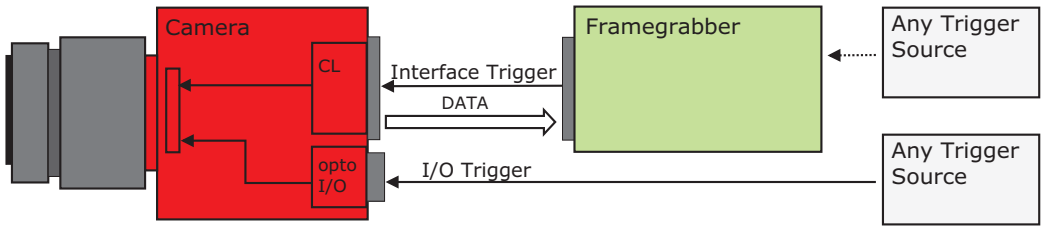

Figure 4.33: Trigger Inputs

4.6.2 Trigger Mode

Depending on the trigger mode, the exposure time can be determined either by the camera or by the trigger signal itself:

Camera-controlled Exposure In this trigger mode the exposure time is defined by the camera. For an active high trigger signal, the camera starts the exposure with a positive trigger edge and stops it when the preprogrammed exposure time has elapsed. The exposure time is defined by the software.

Level-controlled Exposure In this trigger mode the exposure time is defined by the pulse width of the trigger pulse. For an active high trigger signal, the camera starts the exposure with the positive edge of the trigger signal and stops it with the negative edge.

Level-controlled Exposure is not available in simultaneous readout mode.

Figure 4.34 gives an overview over the available trigger modes. The signal `ExSync` stands for the trigger signal, which is provided either through the interface or the I/O trigger. For more information and the respective timing diagrams see Section 5.4

	Polarity Active High		Polarity Active Low	
	Exposure Start	**Exposure Stop**	**Exposure Start**	**Exposure Stop**
Camera controlled exposure	ExSync	Camera	ExSync	Camera
Level controlled exposure	ExSync	ExSync	ExSync	ExSync

Rising Edge
Falling Edge

Figure 4.34: Trigger Inputs

4.6.3 Trigger Delay

Programmable delay in milliseconds between the incoming trigger edge and the start of the exposure. This feature may be required to synchronize to external strobe with the exposure of the camera.

4.6.4 Trigger Resolution

For a succesfull 3D image acquisition it is important to use the encoder pulses from the conveyer belt or a similar device for triggering the image acquisition of the camera. However, it may occur that the delivered encoder pulse frequency exceeds the requirements of the 3D application. To allow for exact configuration of the image acquisition system the Trigger Resolution feature allows to skip a predefined number of trigger pulses delivered from the incremental encoder.

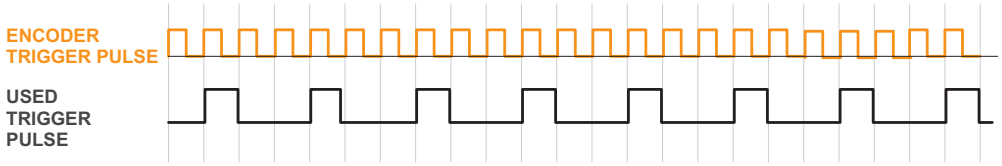

Figure 4.35: Timing in Trigger Resolution mode. Example: Applying a Trigger Resolution value of 2 will skip two trigger pulses from the incremental encoder and capture images upon every 3rd trigger pulse.

4.7 Strobe Output

The strobe output is an opto-isolated output located on the power supply connector that can be used to trigger a strobe. The strobe output can be used both in free-running and in trigger mode. There is a programmable delay available to adjust the strobe pulse to your application.

The strobe output needs a separate power supply. Please see Section 5.1.3 for more information.

4.8 Additional 3D Functionality

4.8.1 Mode Settings

The Peak Detector functionality in the MV-D1024E-3D01-160 camera can be configured in different modes, depending on what image information should be transfered from the camera to the frame grabber. The following settings can be selected:

2D Mode

In the 2D mode the camera sends raw image data to the frame grabber, which can then be further processed on the frame grabber or by an image processing software tool. No additional 3D information is transferred with the raw image data when using the 2D mode.

Combined 2D/3D Mode

In the combined 2D/3D mode the camera sends the raw image data including the necessary 3D information to the frame grabber. The raw image containing the laser line is analyzed by the Peak Detector in the camera's FPGA. This 3D information is then attached to the 2D raw image.

The laser line needs to be aligned in vertical orientation towards the camera.

Only a single vertical laser line can be processed at a time by the 3D Peak Detector algorithm.

If your application requires to process multiple laser lines please contact Photonfocus to discuss possible firmware adaptions.

The combined 2D/3D mode is typically used for simultaneous image analysis of 2D and 3D images or to set up the laser triangulation system.

3D Mode

In the 3D mode the camera only sends the 3D data calculated by the Peak Detector algorithm in the camera FPGA to the frame grabber.

4.8.2 Threshold

The raw image data are first processed by the threshold pre-filter before being analyzed by the Peak Detector algorithm.

The threshold must be set above the image background otherwise the 3D data may be incorrect.

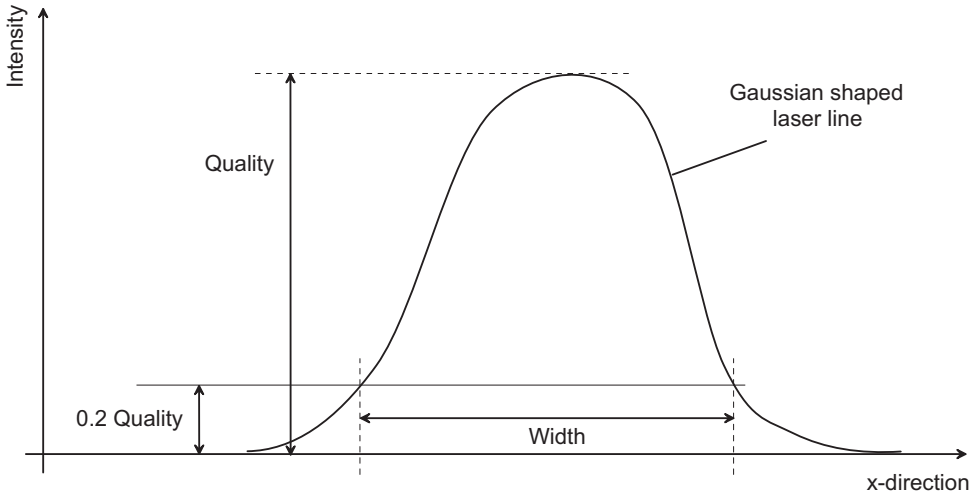

Figure 4.36: The peak width is determined by the subtraction of a baseline, that equals 0.2 quality

4.8.3 Insertion of 3D Data

The 2D raw image data is analyzed row by row by the Peak Detector algorithm, and at the end of each row an 8 byte data block with 3D specific information is attached. For details of 3D data storage format see Section 4.8.4. The assignment of the 8 byte (8 x 8 bit) 3D data block is shown in Fig. 4.38.

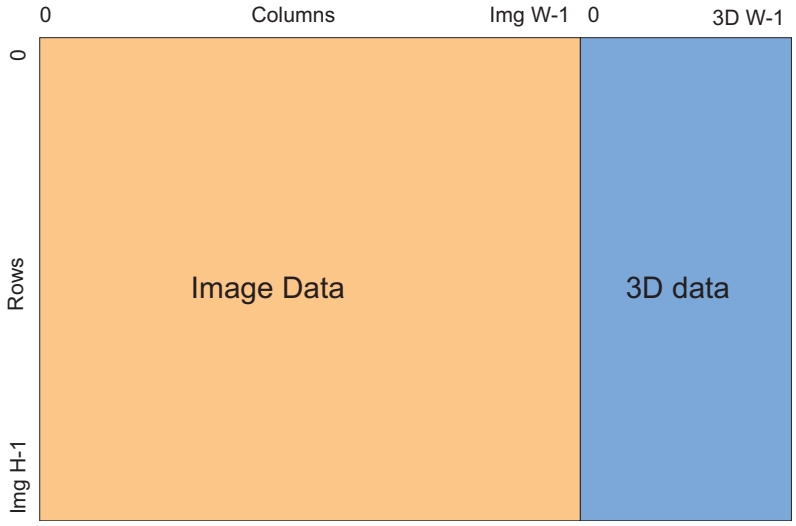

Figure 4.37: Data arrangement in the 2D + 3D mode

PEAK [15:8]	PEAK [7:0]	WIDTH [7:0]	QUAL [gr-1:0]	RESERVED	RESERVED	RESERVED	RESERVED
0	1	2	3	4	5	6	7

Figure 4.38: 3D data byte assignment ("gr" represents the greyscale resolution)

The 3D data block contains the following information:

- Peak coordinate (2 bytes). The 1st and the 2nd byte (PEAK [15:0]) indicate the calculated peak position of the laser line within the 2D raw image. PEAK [15:6] is the integer part of the peak coordinate and PEAK [5:0] is the fractional part.
- Laser line width (1 byte). The 3rd byte (WIDTH [7:0]) contains the width of the laser line (see Fig. 4.36). WIDTH [7:2] is the integer part and WIDTH [1:0] is the fractional part.
- Detection quality indicator (1 word). The 4th byte (QUAL [(gr-1):0]) contains the maximum height of the laser line (see Fig. 4.36). For the bit assignment of the quality indicator in 8 bit, 10 bit or 12 bit greyscale resolution see Table 4.6. In this context the abbreviation "gr" is used for the greyscale resolution (8 bit, 10 bit or 12 bit).
- Reserved (4 byte).

Greyscale Resolution	Quality Indicator
8 bit	QUAL[7:0]
10 bit	QUAL[9:0]
12 bit	QUAL[11:0]

Table 4.6: Bit assignment of the quality indicator depends on the greyscale resolution

The 3D data block is always given in 8 bit format, independent of the choosen greyscale resolution, except QUAL. The 8 bit data is located on the LSBs of the pixel and the remaining bits are set to 0.

4.8.4 Interpolation Technique

Structured light based systems crucially rely on an accurate determination of the peak position of the Gaussian shaped laser line. The Peak Detector algorithm in the MV-D1024E-3D01-160 camera applies nonlinear interpolation techniques, where up to 64 data points can be inserted between two pixels within the Gaussian shaped laser line. This technique is superior to other commonly used detection techniques, such as the detection of peak pixel intensity across the laser line (resulting in pixel accuracy) or the thresholding of the Gaussian and calculation of the average (resulting in subpixel accuracy).

The Peak Detector analyzes all image data that are enclosed within the selected region of interest (ROI).

The nonlinear interpolation technique used in the Peak Detector algorithm results in a better estimate of the maximum intensity of the laser line. The data mapping for the 3D data block is shown in Fig. 4.37 and the basics of the interpolation principle are illustrated in Fig. 4.39.

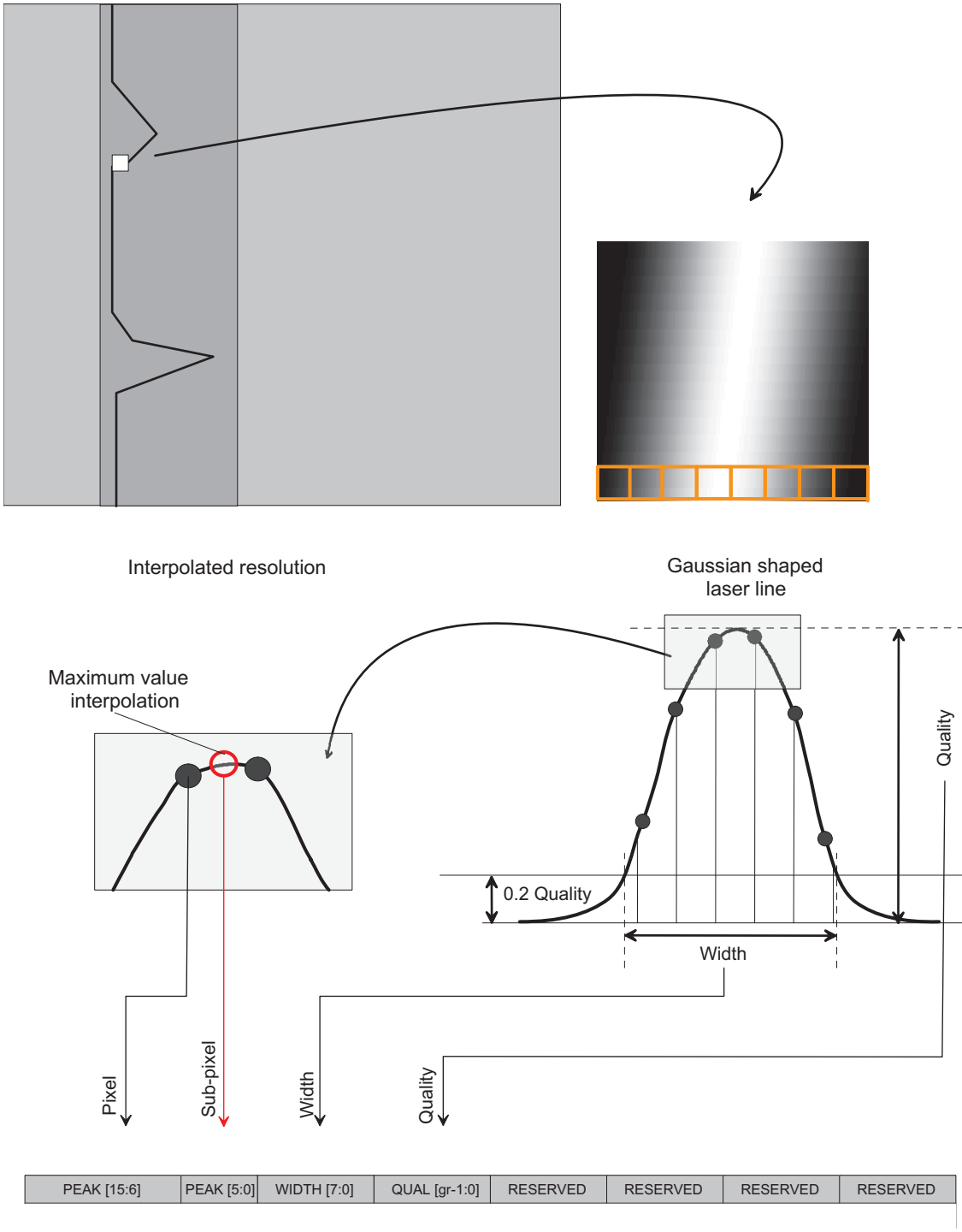

Figure 4.39: Interpolation technique provides sub-pixel accuracy in the detection of the laser peak by inserting up to 64 data points between two pixels ("gr" represents the greyscale resolution).

The line position is split into a coarse position and a fine position (sub-pixel). The coarse position is based on the pixel pitch and is transferred in Peak [15:6]. The sub-pixel position that was calculated from the Peak Detector algorithm (6 bit sub-pixel information) is mapped to Peak [5:0]. The value ranges of the 3D data block are listed in Table 4.7.

If the camera is operating in a greyscale resolution mode higher than 8 bit, then the MSBs are filled by 0 (except for the quality indicator). This means that only bits [7:0] contain the 3D information.

3D Data	Value range
PEAK [15:6]	0 .. 1023
PEAK [5:0]	0 .. 63
WIDTH [7:0]	0 .. 63
WIDTH [1:0]	0 .. 3
QUAL [(gr-1):0]	0 .. (2^{gr} - 1)

Table 4.7: Value ranges of the 3D data block ("gr" indicates the greyscale resolution)

4.9 Configuration Interface (CameraLink)

A CameraLink camera can be controlled by the user via a RS232 compatible asynchronous serial interface. This interface is contained within the CameraLink interface as shown in Fig. 4.40 and is physically not directly accessible. Instead, the serial communication is usually routed through the frame grabber. For some frame grabbers it might be necessary to connect a serial cable from the frame grabber to the serial interface of the PC.

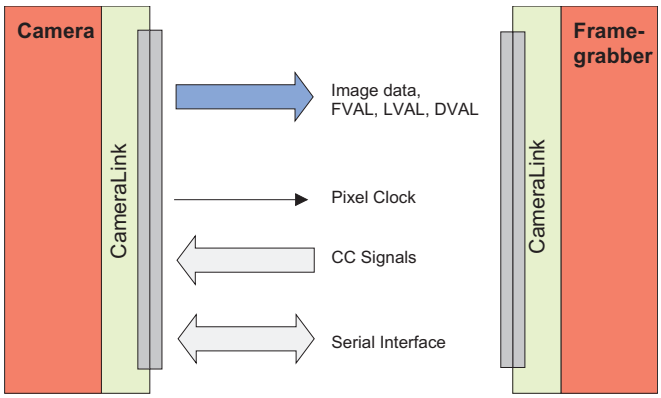

Figure 4.40: CameraLink serial interface for camera communication

5 Hardware Interface

5.1 Connectors

5.1.1 CameraLink Connector for CameraLink Camera Models

The CameraLink cameras are interfaced to external components via

- a CameraLink connector, which is defined by the CameraLink standard as a 26 pin, 0.05" Mini Delta-Ribbon (MDR) connector to transmit configuration, image data and trigger.
- a subminiature connector for the power supply, 7-pin Binder series 712.

The connectors are located on the back of the camera. Fig. 5.1 shows the plugs and the status LED which indicates camera operation.

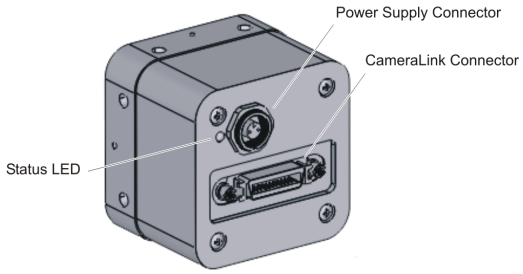

Figure 5.1: Rear view of the CameraLink camera

The CameraLink interface and connector are specified in [CL]. For further details including the pinout please refer to Appendix A. This connector is used to transmit configuration, image data and trigger signals.

5.1.2 Power Supply for CameraLink Camera Models

The camera requires a single voltage input (see Table 3.4). The camera meets all performance specifications using standard switching power supplies, although well-regulated linear power supplies provide optimum performance.

It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage the camera.

A suitable power supply is available from Photonfocus.

For further details including the pinout please refer to Appendix A.

5.1.3 Trigger and Strobe Signals

The power connector contains an external trigger input and a strobe output.

The input voltage to the TRIGGER pin must not exceed +15V DC, to avoid damage to the internal optocoupler!

In order to use the strobe output, the internal optocoupler must be powered with 5 .. 15 V DC. The STROBE signal is an open-collector output, therefore, the user must connect a pull-up resistor (see Table 5.1) to STROBE_VDD (5 .. 15 V DC) as shown in Fig. 5.2. This resistor should be located directly at the signal receiver.

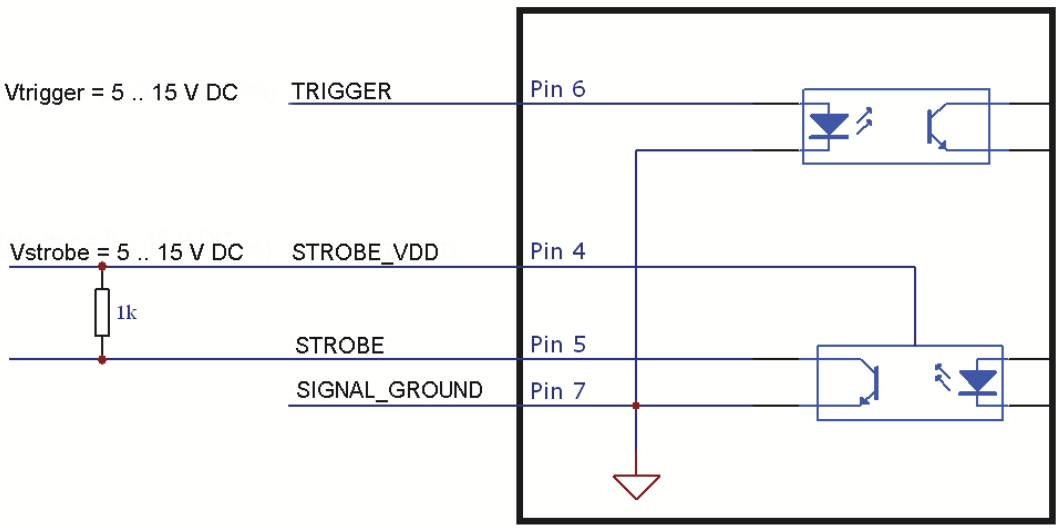

Figure 5.2: Circuit for the trigger input and strobe output signals

The maximum sink current of the STROBE pin is 8 mA. *Do not connect inductive or capacitive loads*, such loads may result in damage of the optocoupler! If the application requires this, please use voltage suppressor diodes in parallel with this components to protect the opto coupler.

The recommended sink current of the TRIGGER pin is 5 mA.

STROBE_VDD	Pull-up Resistor
15 V	> 3.9 kOhm
10 V	> 2.7 kOhm
8V	> 2.2 kOhm
7V	> 1.8 kOhm
5V	> 1.0 kOhm

Table 5.1: Pull-up resistor for strobe output and different voltage levels

5.1.4 Status Indicator (CameraLink Cameras)

A dual-color LED on the back of the camera gives information about the current status of the CameraLink cameras.

LED Green	Green when an image is output. At slow frame rates, the LED blinks with the FVAL signal. At high frame rates the LED changes to an apparently continuous green light, with intensity proportional to the ratio of readout time over frame time.
LED Red	Red indicates an active serial communication with the camera.

Table 5.2: Meaning of the LED of the CameraLink cameras

5.2 CameraLink Data Interface

The CameraLink standard contains signals for transferring the image data, control information and the serial communication. In PoCL camera models the power supply is provided by the same data interface.

Data signals: CameraLink data signals contain the image data. In addition, handshaking signals such as FVAL, LVAL and DVAL are transmitted over the same physical channel.

Camera control information: Camera control signals (CC-signals) can be defined by the camera manufacturer to provide certain signals to the camera. There are 4 CC-signals available and all are unidirectional with data flowing from the frame grabber to the camera. For example, the external trigger is provided by a CC-signal (see Table 5.3 for the CC assignment).

CC1	EXSYNC	External Trigger. May be generated either by the frame grabber itself (software trigger) or by an external event (hardware trigger).
CC2	CTRL0	Control0. This signal is reserved for future purposes and is not used.
CC3	CTRL1	Control1. This signal is reserved for future purposes and is not used.
CC4	CTRL2	Control2. This signal is reserved for future purposes and is not used.

Table 5.3: Summary of the Camera Control (CC) signals as used by Photonfocus

Pixel clock: The pixel clock is generated on the camera and is provided to the frame grabber for synchronisation.

Serial communication: A CameraLink camera can be controlled by the user via a RS232 compatible asynchronous serial interface. This interface is contained within the CameraLink interface and is physically not directly accessible. Refer to Section 4.9 for more information.

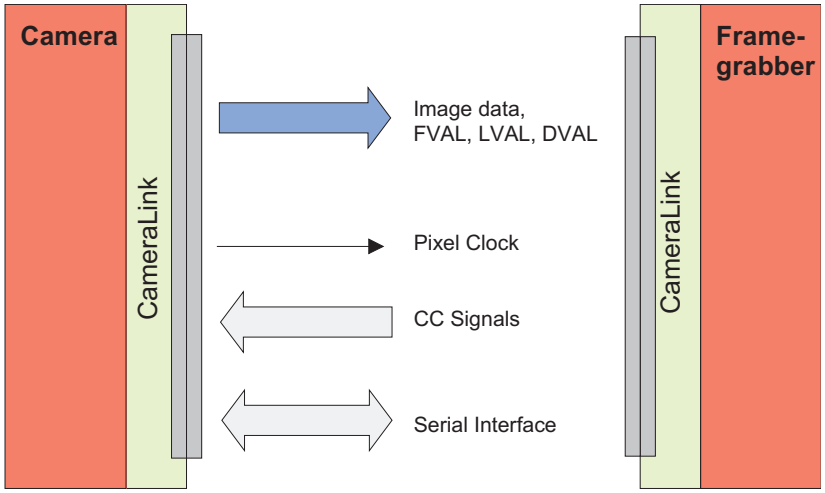

Figure 5.3: 1-tap CameraLink system

The frame grabber needs to be configured with the proper tap and resolution settings, otherwise the image will be distorted or not displayed with the correct aspect ratio. Refer to Section 3.4 for a summarised table of frame grabber relevant specifications. Fig. 5.3 shows symbolically a 1-tap system. For more information about taps refer to [AN021] on the Photonfocus website (www.photonfocus.com).

5.3 Read-out Timing

5.3.1 Free running Mode

Sequential readout timing

By default, the camera is in free running mode and delivers images without any external control signals. The sensor is operated in sequential readout mode, which means that the sensor is read out after the exposure time. Then the sensor is reset, a new exposure starts and the readout of the image information begins again. The data is output on the rising edge of the pixel clock. The signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER indicates the active exposure period of the sensor and is shown for clarity only.

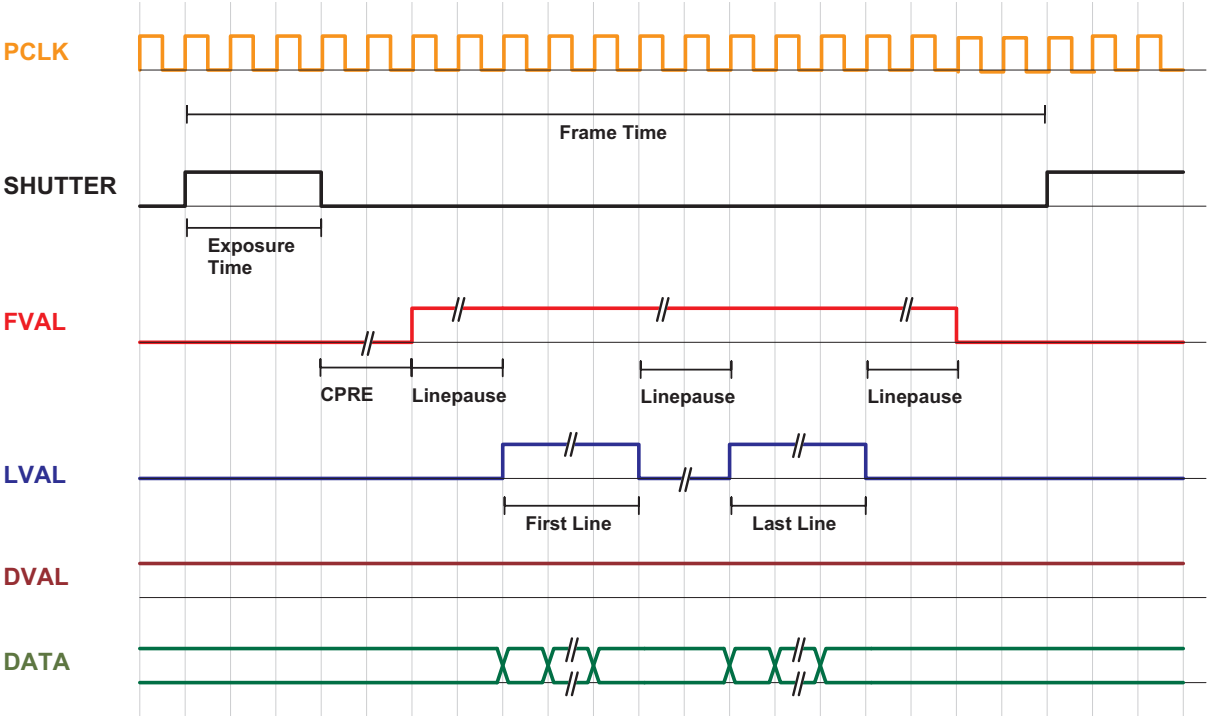

Figure 5.4: Timing diagram sequential readout mode

Simultaneous readout timing

To achieve highest possible frame rates, the camera must be set to "Free-running mode" with simultaneous readout. The camera continuously delivers images as fast as possible. Exposure time of the next image can start during the readout time of the current image. The data is output on the rising edge of the pixel clock. The signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER indicates the active integration phase of the sensor and is shown for clarity only.

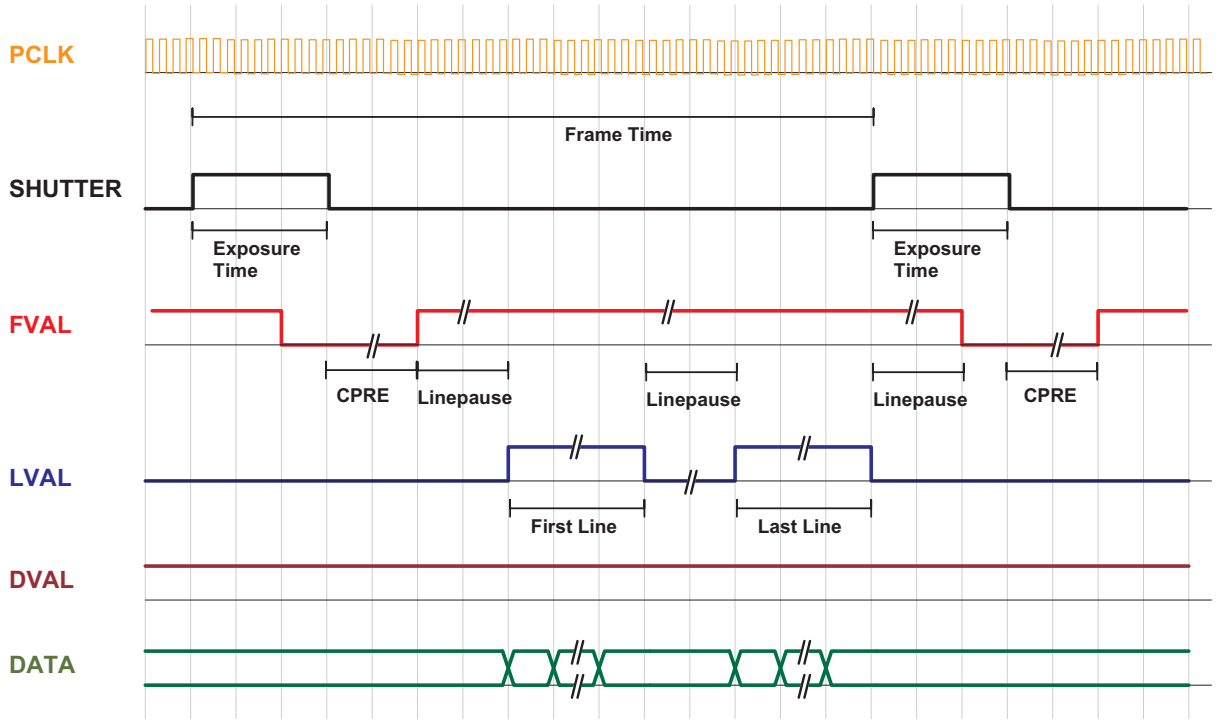

Figure 5.5: Timing diagram simultaneous readout mode (readout time > exposure time)

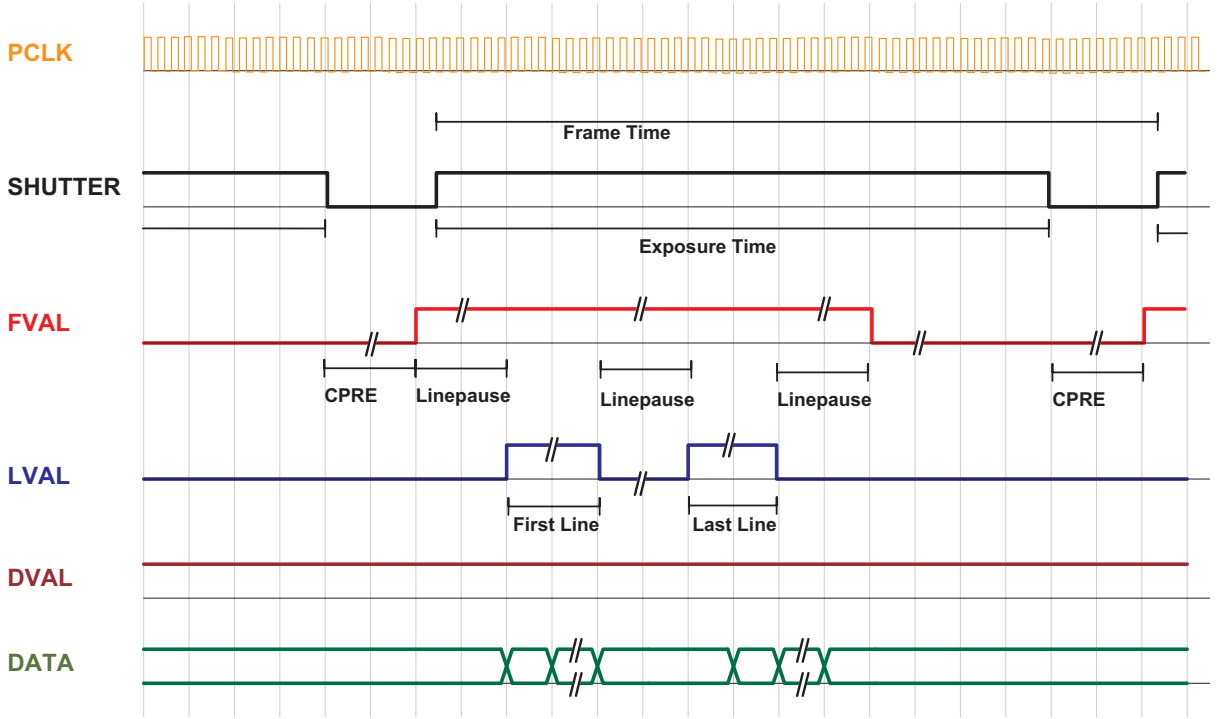

Figure 5.6: Timing diagram simultaneous readout mode (readout time < exposure time)

Frame time	Frame time is the inverse of frame rate.
Exposure time	Period during which the the pixels are integrating the incoming light.
PCLK	Pixel clock on CameraLink interface.
SHUTTER	Internal signal, shown only for clarity. Is 'high' during the exposure time.
FVAL (Frame Valid)	Is 'high' while the data of one whole frame are transferred.
LVAL (Line Valid)	Is 'high' while the data of one line are transferred. Example: To transfer an image with 640x480 pixels, there are 480 LVAL within one FVAL active high period. One LVAL lasts 640 pixel clock cycles.
DVAL (Data Valid)	Is 'high' while data are valid.
DATA	Transferred pixel values. Example: For a 100x100 pixel image, there are 100 values transferred within one LVAL active high period, or 100*100 values within one FVAL period.
Line pause	Delay before the first line and after every following line when reading out the image data.

Table 5.4: Explanation of control and data signals used in the timing diagram

These terms will be used also in the timing diagrams of Section 5.4.

5.3.2 Constant Frame Rate Mode (CFR)

When the camera is in constant frame rate mode, the frame rate can be varied up to the maximum frame rate. Thus, fewer images can be acquired than determined by the frame time. When constant frame rate is switched off, the camera outputs images with maximum speed, depending on the exposure time and the read-out time. The frame rate depends directly on the exposure time.

Constant Frame Rate mode is not available together with external trigger mode.

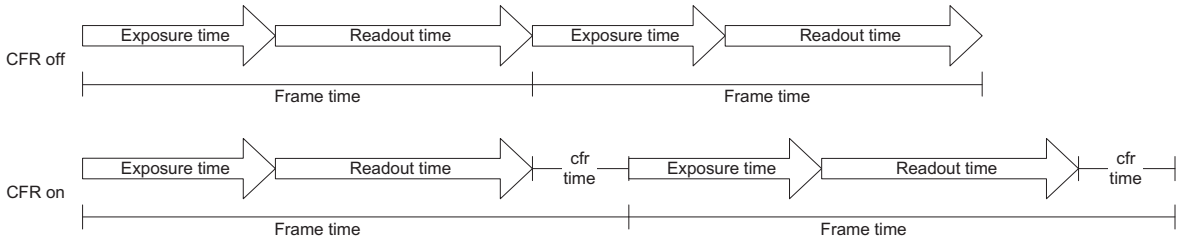

Figure 5.7: Constant Frame Rate with sequential readout mode

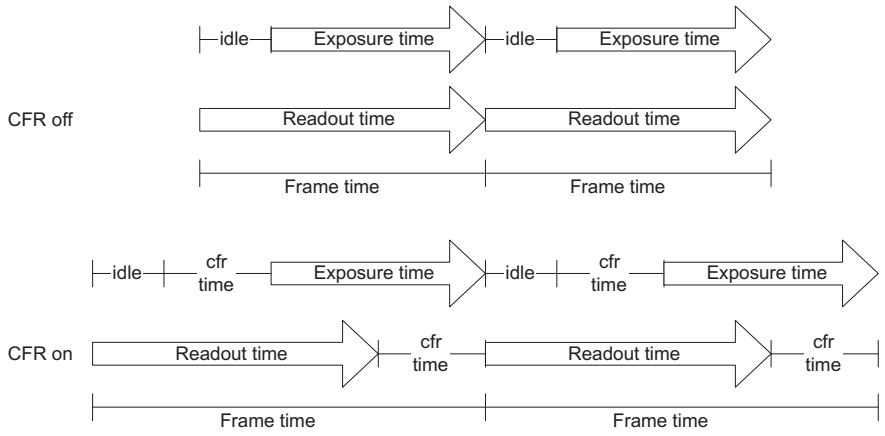

Figure 5.8: Constant Frame Rate with simultaneous readout mode (readout time > exposure time)

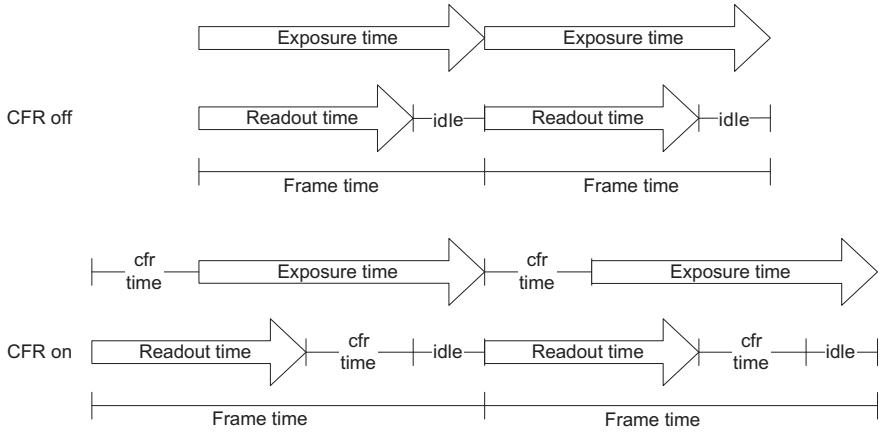

Figure 5.9: Constant Frame Rate with simultaneous readout mode (readout time < exposure time)

5.4 Trigger

5.4.1 Trigger Modes

The following sections show the timing diagram for the trigger modes. The signal ExSync denotes the trigger signal that is provided either by the interface trigger or the I/O trigger (see Section 4.6). The other signals are explained in Table 5.4.

Camera-controlled Exposure

In the camera-controlled trigger mode, the exposure is defined by the camera and is configurable by software. For an active high trigger signal, the image acquisition begins with the rising edge of the trigger signal. The image is read out after the pre-configured exposure time. After the readout, the sensor returns to the reset state and the camera waits for a new trigger pulse (see Fig. 5.10).
The data is output on the rising edge of the pixel clock, the handshaking signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER in Fig. 5.10 indicates the active integration phase of the sensor and is shown for clarity only.

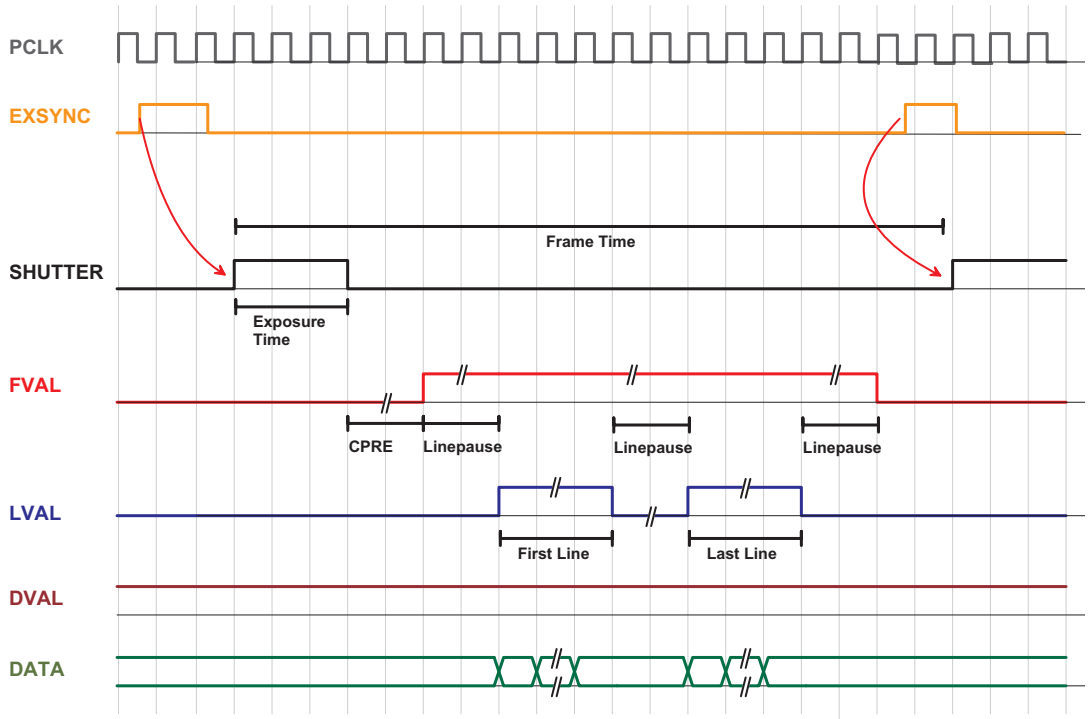

Figure 5.10: Trigger timing diagram for camera controlled exposure

Level-controlled Exposure

In the level-controlled trigger mode, the exposure time is defined by the pulse width of the external trigger signal. For an active high trigger signal, the image acquisition begins with the rising edge and stops with the falling edge of the external trigger signal. Then the image is read out. After that, the sensor returns to the idle state and the camera waits for a new trigger pulse (see Fig. 5.11). The data is output on the rising edge of the pixel clock, the handshaking signals FRAME_VALID (FVAL) and LINE_VALID (LVAL) mask valid image information. The signal SHUTTER in Fig. 5.11 indicates the active integration phase of the sensor and is shown for clarity only.

☞ Level-controlled exposure is not supported in simultaneous readout mode.

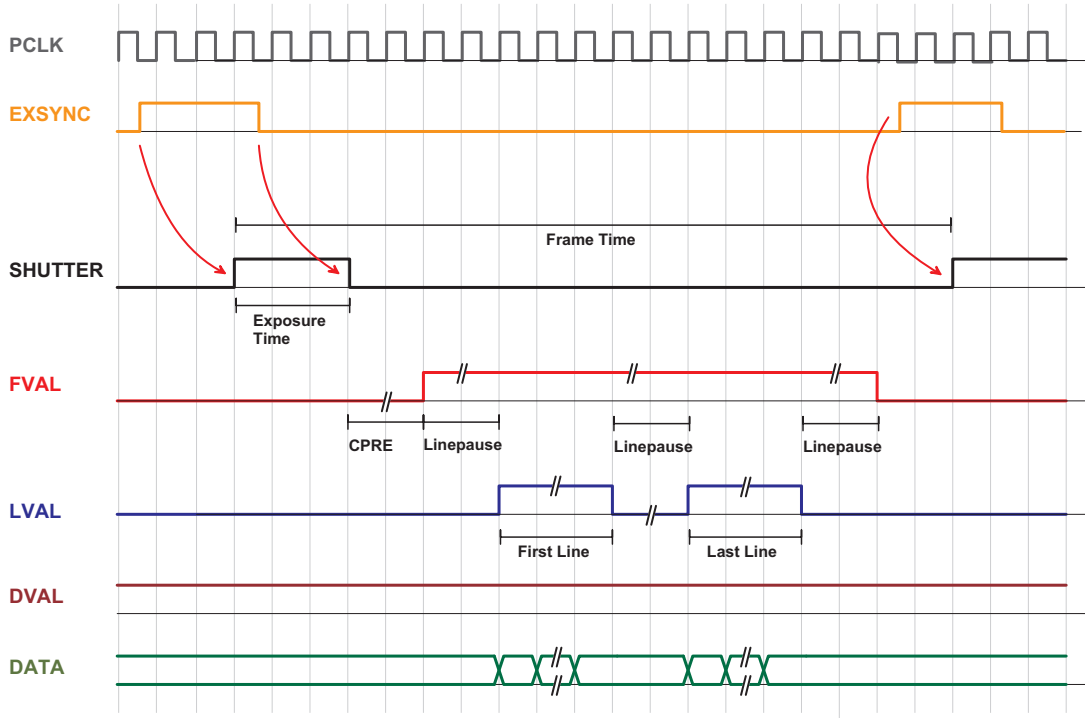

Figure 5.11: Trigger timing diagramm for level controlled exposure

5.4.2 Trigger Delay

The total delay between the trigger edge and the camera exposure consists of the delay in the frame grabber and the camera (Fig. 5.12). Usually, the delay in the frame grabber is relatively large to avoid accidental triggers caused by voltage spikes (see Fig. 5.13). The trigger can also be delayed by the property `Trigger.Delay`.

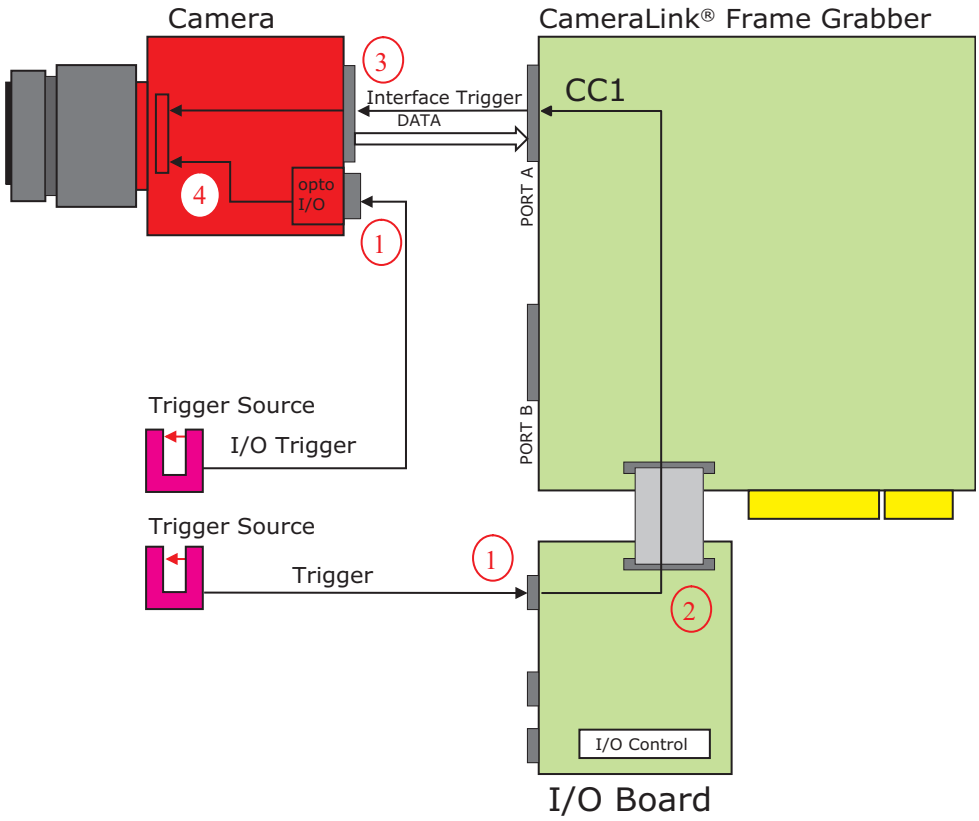

Figure 5.12: Trigger Delay visualisation from the trigger source to the camera

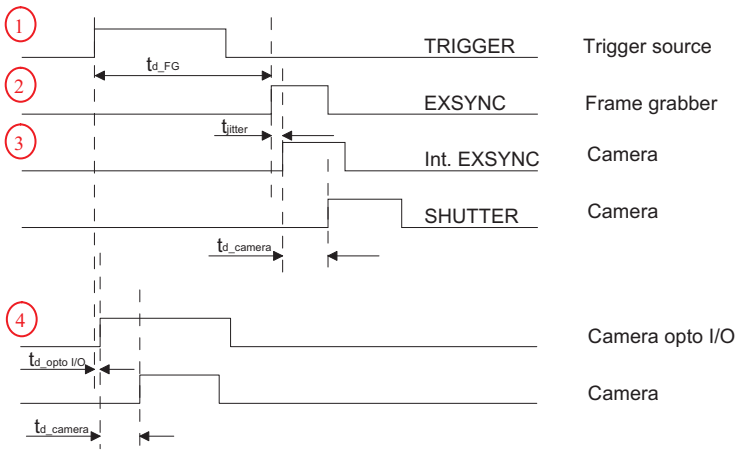

Figure 5.13: Timing Diagram for Trigger Delay

For the delay in the frame grabber, please ask your frame grabber manufacturer. The camera delay consists of a constant trigger delay and a variable delay (jitter).

Trigger delay type	Description
t_{d-FG}	Trigger delay of the frame grabber, refer to frame grabber manual
t_{jitter}	Variable camera trigger delay (max. 25 ns)
$t_{d-camera}$	Constant camera trigger delay (150 ns)
t_{d-opto}	Variable trigger delay of opto coupler

Table 5.5: Trigger Delay

6 The PFRemote Control Tool

6.1 Overview

PFRemote is a graphical configuration tool for Photonfocus cameras. The latest release can be downloaded from the support area of www.photonfocus.com.
All Photonfocus cameras can be either configured by PFRemote, or they can be programmed with custom software using the PFLib SDK ([PFLIB]).

6.2 PFRemote and PFLib

As shown in Fig. 6.1, the camera parameters can be controlled by PFRemote and PFLib respectively. To grab an image use the software or the SDK that was delivered with your frame grabber.

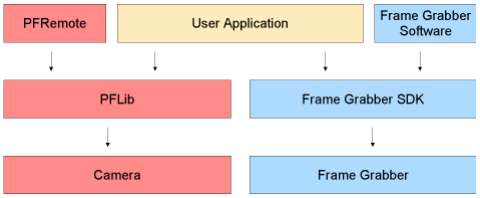

Figure 6.1: PFRemote and PFLib in context with the CameraLink frame grabber software

6.3 Operating System

The PFRemote GUI is available for Windows OS only. For Linux or QNX operating systems, we provide the necessary libraries to control the camera on request, but there is no graphical user interface available.

If you require support for Linux or QNX operating systems, you may contact us for details of support conditions.

6.4 Installation Notes

Before installing the required software with the PFInstaller, make sure that your frame grabber software is installed correctly.
Several DLLs are necessary in order to be able to communicate with the cameras:

- `PFCAM.DLL`: The main DLL file that handles camera detection, switching to specific camera DLL and provides the interface for the SDK.
- `'CAMERANAME'.DLL`: Specific camera DLL, e.g. mv_d1024e_3d01_160.dll.
- `COMDLL.DLL`: Communication DLL. This COMDLL is not necessarily CameraLink specific, but may depend on a CameraLink API compatible DLL, which should also be provided by your frame grabber manufacturer.

- CLALLSERIAL.DLL: Interface to CameraLink frame grabber which supports the clallserial.dll.
- CLSER_USB.DLL: Interface to USB port.

More information about these DLLs is available in the SDK documentation [SW002].

6.5 Graphical User Interface (GUI)

PFRemote consists of a main window (Fig. 6.2) and a configuration dialog. In the main window, the camera port can be opened or closed, and log messages are displayed at the bottom. The configuration dialog appears as a sub window as soon as a camera port was opened successfully. In the sub window of PFRemote the user can configure the camera properties. The following sections describe the general structure of PFRemote.

6.5.1 Port Browser

On start, PFRemote displays a list of available communication ports in the main window.

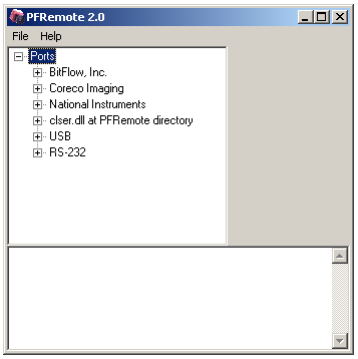

Figure 6.2: PFRemote main window with PortBrowser and log messages

To open a camera on a specific port double click on the port name (e.g. USB). Alternatively right click on the port name and choose **Open & Configure...**. The port is then queried for a compatible Photonfocus camera.
In the PFRemote main window, there are two menus with the following entries available:

File Menu

Clear Log: Clears the log file buffer

Quit: Exit the program

Help Menu

About: Copyright notice and version information

Help F1: Invoke the online help (PFRemote documentation)

6.5.2 Ports, Device Initialization

After starting **PFRemote**, the main window as shown in Fig. 6.2 will appear. In the PortBrowser in the upper left corner you will see a list of supported ports.

Depending on the configuration, your port names may differ, and not every port may be functional.

If your frame grabber supports clallserial.dll version 1.1 (CameraLink compliant standard Oct 2001), the name of the manufacturer is shown in the PortBrowser.

If your frame grabber supports clallserial.dll version 1.0 (CameraLink compliant standard Oct 2000), the PortBrowser shows either the name of the dll or the manufacturer name or displays "Unknown".

If your frame grabber doesn't support clallserial.dll, copy the clserXXXX.dll of your frame grabber in the PFRemote directory and rename it to clser.dll. The PortBrowser will then indicate this DLL as "clser.dll at PFRemote directory".

After connecting the camera, the device can be opened with a double click on the port name or by right-clicking on the port name and choosing **Open & Configure**. If the initialisation of the camera was successful, the configuration dialog will open. The device is closed when PFRemote is closed. Alternatively, e.g. when connecting another camera or evaluation kit, the device can also be closed explicitely by right clicking on the port name and choosing **Close**. Make sure that the configuration dialog is closed prior to closing the port.

Errors, warnings or other important activities are logged in a log window at the bottom of the main window.

If the device does not open, check the following:

- Is the power LED of the camera active? Do you get an image in the display software of your frame grabber?
- Verify all cable connections and the power supply.
- Check the communication LED of the camera: do you see some activity when you try to access the camera?

6.5.3 Main Buttons

The buttons on the right side of the configuration dialog store and reset the camera configuration.

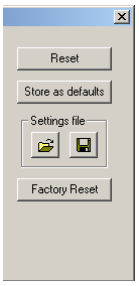

Figure 6.3: Main buttons

Reset: Reset the camera and load the default configuration.

Store as defaults: Store the current configuration in the camera flash memory as the default configuration. After a reset, the camera will load this configuration by default.

Settings file - File Load: Load a stored configuration from a file.

Settings file - File Save: Save current configuration to a file.

Factory Reset: Reset camera and reset the configuration to the factory defaults.

6.6 Device Properties

Cameras or sensor devices are generally addressed as ‘device’ in this software. These devices have properties that are accessed by a property name. These property names are translated into register accesses on the driver DLL. The property names are reflected in the GUI as far as practicable. A property name normally has a special mark up throughout this document, for example: `ExposureTime`. Some properties are grouped into a structure whose member is accessed via dot notation, e.g. `Window.X` (for the start X value of a region of interest). When changing a property, the property name can always be seen in the log window of the main program window.

7

Graphical User Interface (GUI)

7.1 MV-D1024E-3D01-160

This section describes the parameters of the following cameras.

- MV-D1024E-3D01-160-CL, CameraLink interface

The following sections are grouped according to the tabs in the configuration dialog.

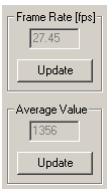

Figure 7.1: MV-D1024E-3D01-160 frame rate and average value

Frame Rate [fps :] Shows the actual frame rate of the camera in frames per second.

Update: To update the value of the frame rate, click on this button.

Average Value: Greyscale average of the actual image. This value is in 12bit (0...4095).

Update: To update the value of the average, click on this button.

7.1.1 Exposure

This tab contains exposure settings.

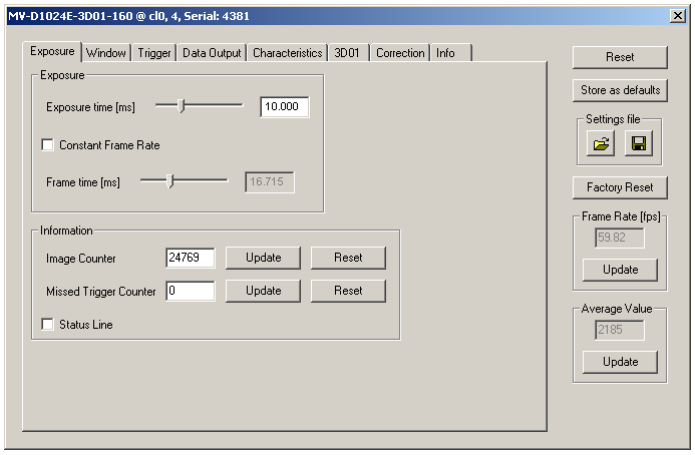

Figure 7.2: MV-D1024E-3D01-160 exposure panel

Exposure

Exposure time [ms :] Configure the exposure time in milliseconds.

Constant Frame Rate: When the Constant Frame Rate (CFR) is switched on, the frame rate (number of frames per second) can be varied from almost 0 up to the maximum frame rate. Thus, fewer images can be acquired than would otherwise be possible. When Constant Frame Rate is switched off, the camera delivers images as fast as possible, depending on the exposure time and the read-out time.

Frame time [ms :] Configure the frame time in milliseconds. Only available if Constant Frame Rate is enabled. The minimum frame time depends on the exposure time and readout time.

Information

The Information properties provide information about the acquired images.

Image Counter: The image counter is a 24 bit real-time counter and is incremented by 1 for every new image.

Missed Trigger Counter: This is a counter for trigger pulses that were blocked because the trigger pulse was received during image exposure or readout. In free-running mode it counts all pulses received from interface trigger or from I/O trigger interface.

Status Line: The status line replaces the last line of an image with image information.

To update the value of the information properties, click on the Update-Button; to reset the properties, click on the Reset-Button.

7.1.2 Window

This tab contains ROI, multi-ROI and decimation settings.

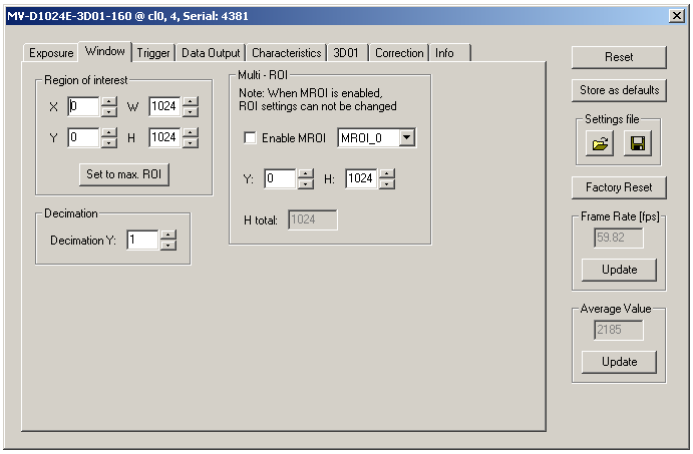

Figure 7.3: MV-D1024E-3D01-160 window panel

Region of Interest

The region of interest (ROI) is defined as a rectangle (X, Y), (W, H) where

X: X - coordinate, starting from 0 in the upper left corner.

Y: Y - coordinate, starting from 0 in the upper left corner.

W: Window width (in steps of 4 pixel).

H: Window height.

Set to max ROI: Set Window to maximal ROI (X=0; Y=0; W=1024; H=1024).

Window width is only available in steps of 4 pixel.

Decimation

`Decimation` reduces the number of pixels in y-direction. Decimation can also be used together with a ROI or MROI. Decimation in y-direction transfers every n-th row only and directly results in reduced read-out time and higher frame rate respectively.

Decimation Y: Decimation value for y-direction. Example: Value = 4 reads every fourth row only.

Multi - ROI

The MV-D1024E-3D01-160 cameras can handle up to 16 different regions of interest. The multiple ROIs are joined together and form a single image, which is transferred to the frame grabber. An ROI is defined by its starting value in y-direction and its height. The width and the horizontal offset are specified by X and W settings. The maximum frame rate in MROI mode

depends on the number of rows and columns being read out. Overlapping ROIs are allowed, and the total height may exceed 1024 rows.

Enable MROI: Enable MROI. If MROI is enabled, the ROI and MROI settings cannot be changed.

MROI_X: Select one of the MROI settings.

Y: Y - coordinate of the selected MROI. If Y is set to 1023, this and all further MROI settings will be ignored.

H: Height of the selected MROI.

H tot: Shows the sum of all MROIs as the total image height.

After changing a property, always press Enter in order to make the change active.

7.1.3 Trigger

This tab contains trigger and strobe settings.

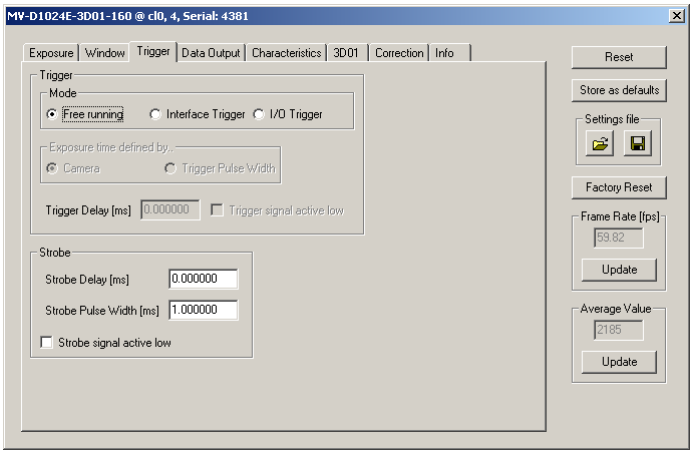

Figure 7.4: MV-D1024E-3D01-160 trigger panel

Trigger

Trigger Source:

Free running: The camera continuously delivers images with a certain configurable frame rate.

Interface Trigger: The Trigger signal is applied to the camera by the CameraLink frame grabber or the USB interface respectively.

I/O Trigger: The trigger signal is applied directly to the camera on the power supply connector.

Exposure time defined by:

Camera: The exposure time is defined by the property `ExposureTime`.

Trigger Pulse Width: The exposure time is defined by the pulse width of the trigger signal (level-controlled exposure).

☞ This property disables LinLog and simultaneous readout mode.

Further trigger settings:

Trigger Delay: Programmable delay in milliseconds between the incoming trigger edge and the start of the exposure.

Trigger signal active low: Define the trigger signal to be active high (default) or active low.

Strobe

The camera generates a strobe output signal that can be used to trigger a strobe. The delay, pulse width and polarity can be defined by software. To turn off strobe output, set StrobePulseWidth to 0.

Strobe Delay [ms :] Delay in milliseconds from the input trigger edge to the rising edge of the strobe output signal.

Strobe Pulse Width [ms :] The pulse width of the strobe trigger in milliseconds.

Strobe signal active low: Define the strobe output to be active high (default) or active low.

7.1.4 Data Output

This tab contains image data settings.

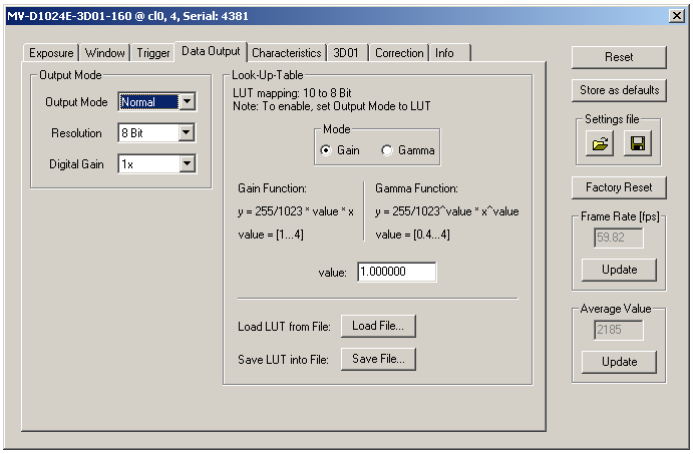

Figure 7.5: MV-D1024E-3D01-160 data output panel

Output Mode

Output Mode:

Normal: Normal mode.

LFSR: Test image. Linear feedback shift register (pseudo-random image). The pattern depends on the grey level resolution.

Ramp: Test image. Values of pixel are incremented by 1, starting at each row. The pattern depends on the grey level resolution.

LUT: Look-Up-Table, a 10-to-8-bit mapping of grey levels.

Resolution:

8 Bit: Grey level resolution of 8 bit.

10 Bit: Grey level resolution of 10 bit.

12 Bit: Grey level resolution of 12 bit.

Digital Gain:

1x: No digital gain, normal mode.

2x: Digital gain 2.

4x: Digital gain 4.

Look-Up-Table

Grey level transformation is remapping of the grey level values of an input image to new values which transform the image in some way. The look-up-table (LUT) is used to convert the greyscale value of each pixel in an image into another grey value. It is typically used to implement a transfer curve for contrast expansion.
The MV-D1024E-3D01-160 camera performs a 10-to-8-bit mapping, so that 1024 input grey levels can be mapped to 256 output grey levels (0 to 1023 and 0 to 255).
The default LUT is a gain function with value = 1.
Lut Mode:

Gain: Linear function. Y = 255 / 1023 * value * X; Valid range for `value` [1...4].

Gamma: Gamma function. Y = 255 / 1023^value * X ^ value; Valid range for `value` [0.4...4].

value: Enter a value. The LUT will be calculated and downloaded to the camera.

Load File...: Load a user defined LUT - file into the camera (*.txt tab delimited). There is an example in the PFRemote directory (mv_d1024e_3d01_160_lut.txt).

Save File...: Save LUT from camera into a file.

It is also possible to load a user LUT-file with missing input values (LUT-addresses). Then only pixel values corresponding to listed LUT entries will be overwritten. Example of a user defined LUT file:

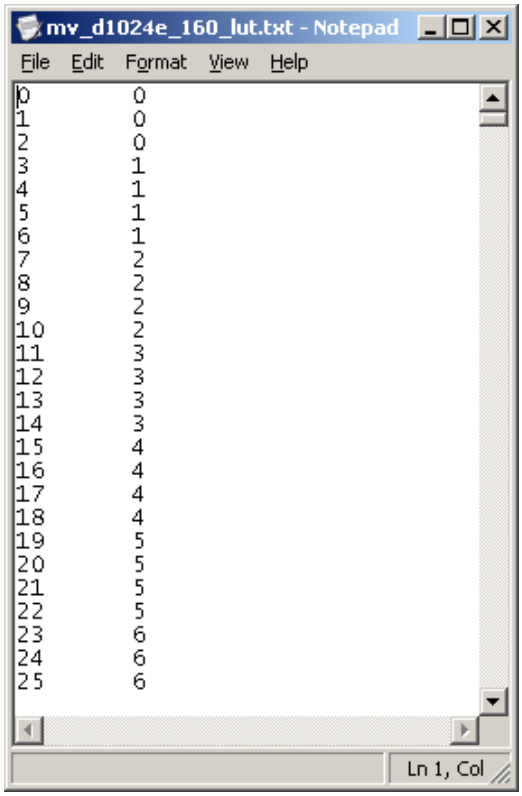

Figure 7.6: Example of a user defined LUT file

7.1.5 Characteristics

This tab contains LinLog and Skimming settings.

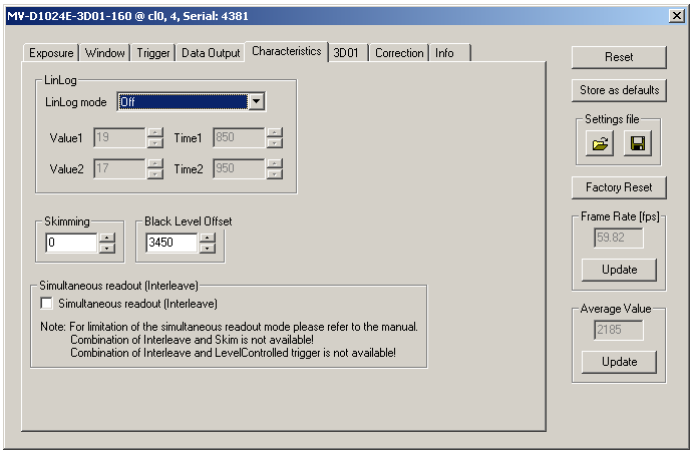

Figure 7.7: MV-D1024E-3D01-160 characteristics panel

LinLog

The LinLog technology from Photonfocus allows a logarithmic compression of high light intensities. In contrast to the classical non-integrating logarithmic pixel, the LinLog pixel is an integrating pixel with global shutter and the possibility to control the transition between linear and logarithmic mode (Section 4.3.2). There are 3 predefined LinLog settings available. Alternatively, custom settings can be defined in the `User defined` Mode.

LinLog Mode: Off: LinLog is disabled. Low/Normal/High compression: Three LinLog presettings. User defined: `Value1`, `Time1`, `Value2` and `Time2`. The Linlog times are per thousand of the exposure time. Time 800 means 80% of the exposure time.

Skimming

Skimming is a Photonfocus proprietary technology to enhance detail in dark areas of an image.

Skimming: Skimming value. If 0, Skimming is disabled. See Section 4.3.3.

Black Level Offset

It may be necessary to adjust the black level offset of the camera.

Black Level Offset: Black level offset value. Use this to adjust the black level.

Simultaneous readout (Interleave)

The simultaneous readout mode allows higher frame rate.

Simultaneous readout (Interleave): Enable the simultaneous readout mode.

Combination of property `Trigger.Interleave` and property `Skim` is not available! Combination of property `Trigger.Interleave` and property `Trigger.LevelControlled` is not available!

7.1.6 3D01

This tab contains the 3D settings.

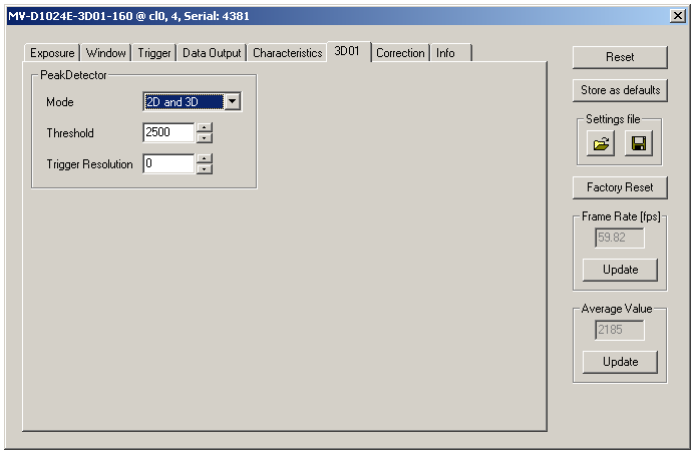

Figure 7.8: MV-D1024E-3D01-160 3D01 panel

Peak Detector

Mode:

2D only: In the 2D mode the camera sends raw image data to the frame grabber, which can then be further processed on the frame grabber or by an image processing software tool. No additional 3D information is transferred with the raw image data when using the 2D mode.

2D and 3D: In the 2D and 3D mode the camera sends the raw image data including the necessary 3D information to the frame grabber. The raw image containing the laser line is analyzed by the Peak Detector in the camera's FPGA. This 3D information is then attached to the 2D raw image. The 2D and 3D mode is typically used for simultaneous image analysis of 2D and 3D images or to set up the laser triangulation system.

3D only: In the 3D mode the camera only sends the 3D data calculated by the Peak Detector algorithm in the camera FPGA to the frame grabber. No raw image data will be transfered to the frame grabber.

Threshold: The raw image data is first processed by the threshold pre-filter before being analyzed by the Peak Detector algorithm. The threshold value is based on 12 bit data resolution, independent of the current data resolution setting. Value range: 0 ... 4095.

Trigger Resolution: For a succesful 3D image acquisition it is important to use the encoder pulses from the conveyer belt or from a similar setup (e.g. a linear actuator) for triggering the image acquisition of the camera. However, it may occur that the delivered pulse frequency from the conveyer belt or from a similar setup exceeds the requirements of the 3D application. For the exact configuration of the image acquisition system the Trigger Resolution feature allows a predefined number of trigger pulses delivered from the conveyer belt to be skipped. Example: A value of 2 will skip two trigger pulses from the conveyer belt (or from a similar setup, e.g. a linear actuator) and capture images upon every 3rd trigger pulse.

7.1.7 Correction

This tab contains correction settings.

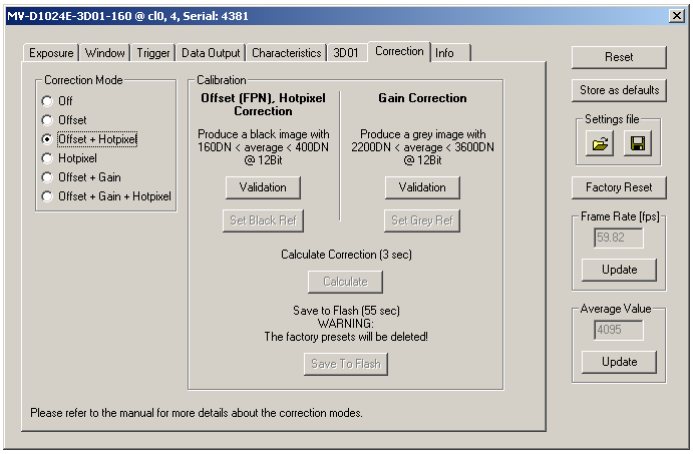

Figure 7.9: MV-D1024E-3D01-160 correction panel

Correction Mode

This camera has image pre-processing features, that compensate for non-uniformities caused by the sensor, the lens or the illumination.

Off: No correction.

Offset: Activate offset correction

Offset + Hotpixel: Activate offset and hot pixel correction.

Hotpixel: Activate hot pixel correction.

Offset + Gain: Activate offset and gain correction.

Offset + Gain + Hotpixel: Activate offset, gain and hot pixel correction.

Calibration

Offset (FPN), Hotpixel Correction: The offset correction is based on a black reference image, which is taken at no illumination (e.g. lens aperture completely closed). The black reference image contains the fixed-pattern noise of the sensor, which can be subtracted from the live images in order to minimize the static noise. Close the lens of the camera. Click on the Validation button. If the Set Black Ref - button is still inactive, the average of the image is out of range. Change to panel Charateristics and change the Property `BlackLevelOffset` until the average of the image is between 160 and 400DN. Click again on the Validation button and then on the Set Black Ref Button.

If only offset and hot pixel correction is needed it is not necessary to calibrate a grey image (see Calculate).

Gain Correction: The gain correction is based on a grey reference image, which is taken at uniform illumination to give an image with a mid grey level.

Gain correction is not a trivial feature. The quality of the grey reference image is crucial for proper gain correction.

Produce a grey image with an average between 2200 and 3600DN. Click on the Validation button to check the average. If the average is in range, the Set Grey Ref button is active.

Calculate: Calculate the correction values into the camera RAM. To make the correction values permanent, use the 'Save to Flash' button.

Save to Flash: Save the current correction values to the internal flash memory.

This will overwrite the factory presets.

7.1.8 Info

This panel shows camera specific information such as type code, serial number and firmware revision of the FPGA and microcontroller and the description of the camera interface.

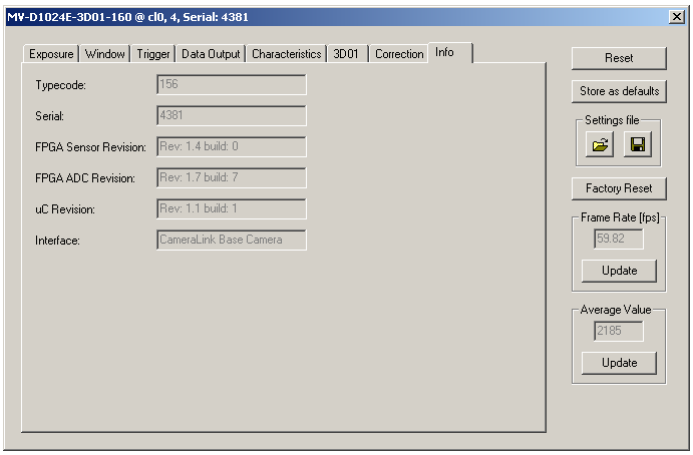

Figure 7.10: MV-D1024E-3D01-160 info panel

Typecode: Type code of the connected camera.

Serial: Serial number of the connected camera.

FPGA Sensor Revision: Firmware revision of built-in Sensor FPGA of the connected camera.

FPGA ADC Revision: Firmware revision of built-in ADC FPGA of the connected camera.

uC Revision: Firmware revision of built-in microcontroller of the connected camera.

Interface: Description of the camera interface.

☞ For any support requests, please enclose the information provided on this tab.

8

Mechanical and Optical Considerations

8.1 Mechanical Interface for CameraLink Camera Models

The general mechanical data of the camera are listed in Section 3, Table 3.4.
During storage and transport, the camera should be protected against vibration, shock, moisture and dust. The original packaging protects the camera adequately from vibration and shock during storage and transport. Please either retain this packaging for possible later use or dispose of it according to local regulations. Fig. 8.1 shows the mechanical drawings of the CameraLink camera models. Table 8.1 summarizes model-specific parameters.

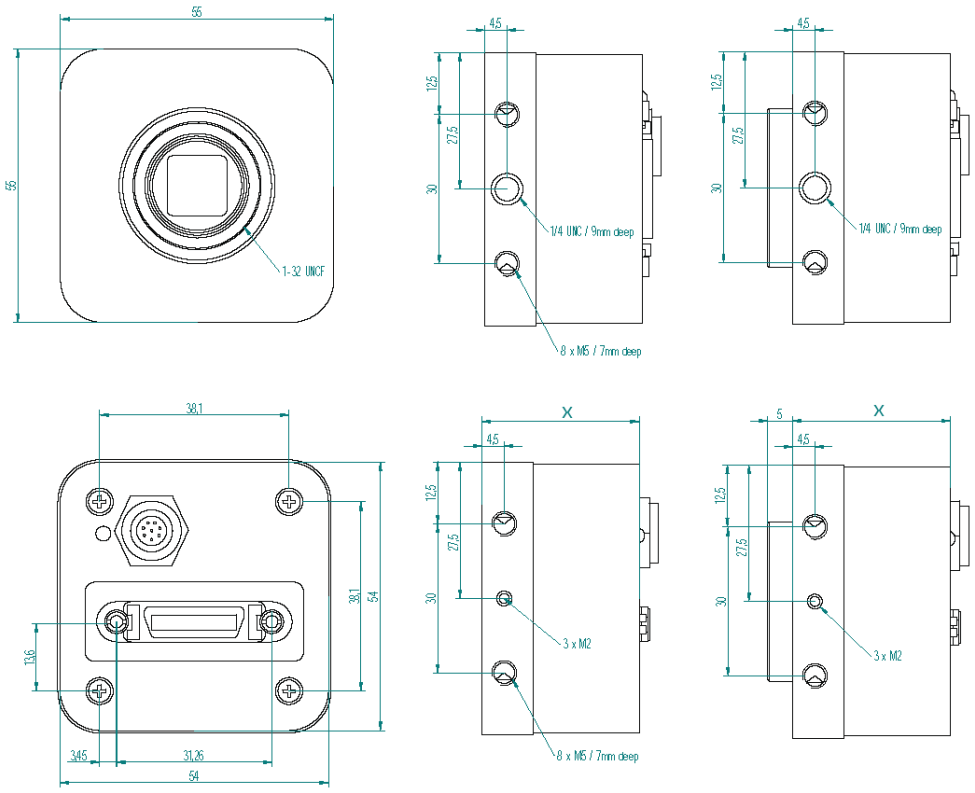

Figure 8.1: Mechanical dimensions of the CameraLink model with or without C-Mount adapter

All values are in [mm].

	MV-D1024E-3D01-160
X (housing depth)	40 mm

Table 8.1: Model-specific parameters

8.2 Optical Interface

8.2.1 Cleaning the Sensor

The sensor is part of the optical path and should be handled like other optical components: **with extreme care**.
Dust can obscure pixels, producing dark patches in the images captured. Dust is most visible when the illumination is collimated. Dark patches caused by dust or dirt shift position as the angle of illumination changes. Dust is normally not visible when the sensor is positioned at the exit port of an integrating sphere, where the illumination is diffuse.

1. The camera should only be cleaned in ESD-safe areas by ESD-trained personnel using wrist straps. Ideally, the sensor should be cleaned in a clean environment. Otherwise, in dusty environments, the sensor will immediately become dirty again after cleaning.
2. Use a high quality, low pressure air duster (e.g. Electrolube EAD400D, pure compressed inert gas, www.electrolube.com) to blow off loose particles. This step alone is usually sufficient to clean the sensor of the most common contaminants.

   Workshop air supply is not appropriate and may cause permanent damage to the sensor.

3. If further cleaning is required, use a suitable lens wiper or Q-Tip moistened with an appropriate cleaning fluid to wipe the sensor surface as described below. Examples of suitable lens cleaning materials are given in Table 8.2. Cleaning materials must be ESD-safe, lint-free and free from particles that may scratch the sensor surface.

   Do not use ordinary cotton buds. These do not fulfil the above requirements and permanent damage to the sensor may result.

4. Wipe the sensor carefully and slowly. First remove coarse particles and dirt from the sensor using Q-Tips soaked in 2-propanol, applying as little pressure as possible. Using a method similar to that used for cleaning optical surfaces, clean the sensor by starting at any corner of the sensor and working towards the opposite corner. Finally, repeat the procedure with methanol to remove streaks. It is imperative that no pressure be applied to the surface of the sensor or to the black globe-top material (if present) surrounding the optically active surface during the cleaning process.

Product		Supplier	Remark
EAD400D	Airduster	Electrolube, UK	www.electrolube.com
Anticon Gold 9"x 9"	Wiper	Milliken, USA	ESD safe and suitable for class 100 environments. www.milliken.com
TX4025	Wiper	Texwipe	www.texwipe.com
Transplex	Swab	Texwipe	
Small Q-Tips SWABS BB-003	Q-tips	Hans J. Michael GmbH, Germany	www.hjm-reinraum.de
Large Q-Tips SWABS CA-003	Q-tips	Hans J. Michael GmbH, Germany	
Point Slim HUBY-340	Q-tips	Hans J. Michael GmbH, Germany	
Methanol	Fluid	Johnson Matthey GmbH, Germany	Semiconductor Grade 99.9% min (Assay), Merck 12,6024, UN1230, slightly flammable and poisonous. www.alfa-chemcat.com
2-Propanol (Iso-Propanol)	Fluid	Johnson Matthey GmbH, Germany	Semiconductor Grade 99.5% min (Assay) Merck 12,5227, UN1219, slightly flammable. www.alfa-chemcat.com

Table 8.2: Recommended materials for sensor cleaning

For cleaning the sensor, Photonfocus recommends the products available from the suppliers as listed in Table 8.2.

Cleaning tools (except chemicals) can be purchased from Photonfocus (www.photonfocus.com).

8.3 Compliance

CE Compliance Statement

We,

Photonfocus AG,
CH-8853 Lachen, Switzerland

declare under our sole responsibility that the following products

MV-D1024-28-CL-10, MV-D1024-80-CL-8, MV-D1024-160-CL-8

MV-D752-28-CL-10, MV-D752-80-CL-8, MV-D752-160-CL-8

MV-D640-33-CL-10, MV-D640-66-CL-10, MV-D640-48-U2-8
MV-D640C-33-CL-10, MV-D640C-66-CL-10, MV-D640C-48-U2-8

MV-D1024E-40, MV-D752E-40, MV-D750E-20 (CameraLink and USB2.0 Models), MV-D1024E-80, MV-D1024E-160

MV-D1024E-3D01-160

MV2-D1280-640-CL-8

SM2-D1024-80 / VisionCam PS

DS1-D1024-40-CL, DS1-D1024-40-U2,
DS1-D1024-80-CL, DS1-D1024-160-CL

DS1-D1312-160-CL, MV1-D1312-160-CL

Digipeater CLB26

are in compliance with the below mentioned standards according to the provisions of European Standards Directives:

EN 61 000 - 6 - 3 : 2001
EN 61 000 - 6 - 2 : 2001
EN 61 000 - 4 - 6 : 1996
EN 61 000 - 4 - 4 : 1996
EN 61 000 - 4 - 3 : 1996
EN 61 000 - 4 - 2 : 1995
EN 55 022 : 1994

Photonfocus AG, October 2008

Figure 8.2: CE Compliance Statement

9 Warranty

The manufacturer alone reserves the right to recognize warranty claims.

9.1 Warranty Terms

The manufacturer warrants to distributor and end customer that for a period of two years from the date of the shipment from manufacturer or distributor to end customer (the "Warranty Period") that:

- the product will substantially conform to the specifications set forth in the applicable documentation published by the manufacturer and accompanying said product, and
- the product shall be free from defects in materials and workmanship under normal use.

The distributor shall not make or pass on to any party any warranty or representation on behalf of the manufacturer other than or inconsistent with the above limited warranty set.

9.2 Warranty Claim

The above warranty does not apply to any product that has been modified or altered by any party other than manufacturer, or for any defects caused by any use of the product in a manner for which it was not designed, or by the negligence of any party other than manufacturer.

10 References

All referenced documents can be downloaded from our website at www.photonfocus.com.

CL CameraLink®Specification, Rev. 1.1, January 2004

SW002 PFLib Documentation, Photonfocus, August 2005

AN001 Application Note "LinLog®", Photonfocus, December 2002

AN024 Application Note "LinLog®- Principle and Practical Example", Photonfocus, March 2005

AN007 Application Note "Camera Acquisition Modes", Photonfocus, March 2004

AN010 Application Note "Camera Clock Concepts", Photonfocus, July 2004

AN021 Application Note "CameraLink®", Photonfocus, July 2004

AN026 Application Note "LFSR Test Images", Photonfocus, September 2005

AN028 Application Note "3D System Configuration", Photonfocus, August 2008

AN030 Application Note "LinLog®Parameter Optimization Strategies", February 2009

MAN040 User Manual "PF 3D Suite", Photonfocus, October 2008

A

Pinouts

A.1 Power Supply for CameraLink Camera Models

The power supply plugs are available from Binder connectors at www.binder-connector.de.

It is extremely important that you apply the appropriate voltages to your camera. Incorrect voltages will damage or destroy the camera.

A suitable power supply is available from Photonfocus.

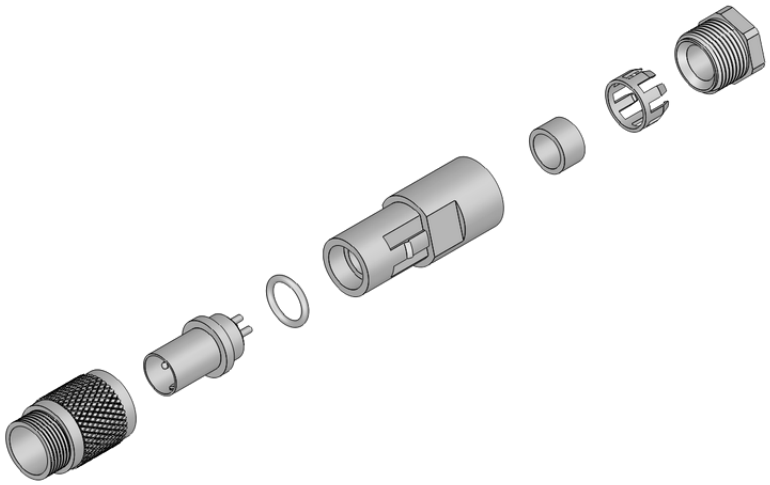

Figure A.1: Power connector assembly

A.1.1 Power Supply Connector

Table A.1 summarizes the order codes for the 7-pole Binder connector. Table A.2 gives the pin assignment for the power supply connector with included I/O ports.

Connector Type	Order Code
7-pole, plastic	99-0421-00-07
7-pole, metal	99-0421-10-07

Table A.1: Power supply connectors (Binder subminiature series 712)

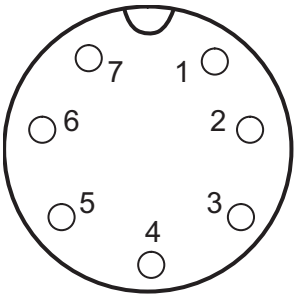

Figure A.2: Power supply plug, 7-pole (rear view of plug, solder side)

Pin	*I/O Type*	*Name*	*Description*
1	PWR	VDD	+12 V DC (± 10%)
2	PWR	GND	Ground
3	O	RESERVED	Do not connect
4	PWR	STROBE-VDD	+5 .. +15 V DC
5	O	STROBE	Strobe control (opto-isolated)
6	I	TRIGGER	External trigger (opto-isolated), +5 .. +15V DC
7	PWR	GROUND	Signal ground (for opto-isolated strobe signal)

Table A.2: Power supply plug pin assignment

A.2 CameraLink Connector for CameraLink Camera Models

The pinout for the CameraLink 26 pin, 0.05" Mini D-Ribbon (MDR) connector is according to the CameraLink standard ([CL]) and is listed here for reference only (see Table A.3). The drawing of the CameraLink cable plug is shown in Fig. A.3. CameraLink cables can be purchased from Photonfocus directly (www.photonfocus.com).

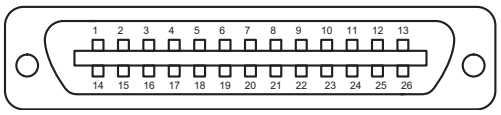

Figure A.3: CameraLink cable 3M MDR-26 plug (both ends)

PIN	IO	Name	Description
1	PW	INNER SHIELD	Inner Shield
2	O	N_XD0	Negative LVDS Output, CameraLink Data D0
3	O	N_XD1	Negative LVDS Output, CameraLink Data D1
4	O	N_XD2	Negative LVDS Output, CameraLink Data D2
5	O	N_XCLK	Negative LVDS Output, CameraLink Clock
6	O	N_XD3	Negative LVDS Output, CameraLink Data D3
7	I	P_SERTOCAM	Positive LVDS Input, Serial Communication to the camera
8	O	N_SERTOFG	Negative LVDS Output, Serial Communication from the camera
9	I	N_CC1	Negative LVDS Input, Camera Control 1 (CC1)
10	I	N_CC2	Positive LVDS Input, Camera Control 2 (CC2)
11	I	N_CC3	Negative LVDS Input, Camera Control 3 (CC3)
12	I	P_CC4	Positive LVDS Input, Camera Control 4 (CC4)
13	PW	INNER SHIELD	Inner Shield
14	PW	INNER SHIELD	Inner Shield
15	O	P_XD0	Positive LVDS Output, CameraLink Data D0
16	O	P_XD1	Positive LVDS Output, CameraLink Data D1
17	O	P_XD2	Positive LVDS Output, CameraLink Data D2
18	O	P_XCLK	Positive LVDS Output, CameraLink Clock
19	O	P_XD3	Positive LVDS Output, CameraLink Data D3
20	I	N_SERTOCAM	Negative LVDS Input, Serial Communication to the camera
21	O	P_SERTOFG	Positive LVDS Output, Serial Communication from the camera
22	I	P_CC1	Positive LVDS Input, Camera Control 1 (CC1)
23	I	N_CC2	Negative LVDS Input, Camera Control 2 (CC2)
24	I	P_CC3	Positive LVDS Input, Camera Control 3 (CC3)
25	I	N_CC4	Negative LVDS Input, Camera Control 4 (CC4)
26	PW	INNER SHIELD	Inner Shield
S	PW	SHIELD	Shield

Table A.3: Pinout CameraLink connector

B

Revision History

Revision	Date	Changes
1.2	August 2010	Section Hardware Interface / Trigger / Trigger Modes / Level-controlled Exposure: corrected bug in tip: level-controlled exposure is not supported in simultaneous readout mode.
		Section Functionality / Image Correction: inserted link to GUI description of image correction.
		Section Mechanical and Optical Considerations / Optical Interface / Cleaning the Sensor: updated link to supplier web page.
1.1	March 2009	Incorporation of improved width calculation method.
		3D data output placed on the 8 LSB of the grey value
		Modified format of width indicator, comprising an integer part and a fractional part
1.0	August 2008	First release